INSTALLATION RESTORATION PROGRAM

AD-A231 664

SOUTH DAKOTA AIR NATIONAL GUARD
JOE FOSS FIELD, SIOUX FALLS, SD

REMEDIAL INVESTIGATION

APPENDICES
VOLUME I
FINAL

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Describes the remedial actions on sites confirmed to contain hazardous waste at Joe Foss Field, Sioux Falls, SD. The report describes the actions taken and the follow-up testing to insure no contamination exists that will endanger human health. The study was conducted under the Air National Guard's Installation Restoration Program.

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SOUTH DAKOTA AIR NATIONAL GUARD
JOSS FOSS FIELD, SIOUX FALLS, SOUTH DAKOTA

APPENDICES
VOLUME I

FINAL

Prepared for:

Air National Guard Support Center
Andrews Air Force Base, Maryland

Prepared by:

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Submitted by:

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Martin Marietta Energy Systems, Inc.

For the

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August 1990

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APPENDIX A:

SOIL BORING AND MONITORING WELL LOGS AND COMPLETION FORMS

BORING LOGS

A summary of the types of information provided in the boring logs is presented in the following paragraphs.

DEPTH

Sample depths were measured in feet below land surface (BLS). The sample depth indicated next to a sample refers to the depth to the top of the sample interval.

ELEVATION (Monitoring well logs only)

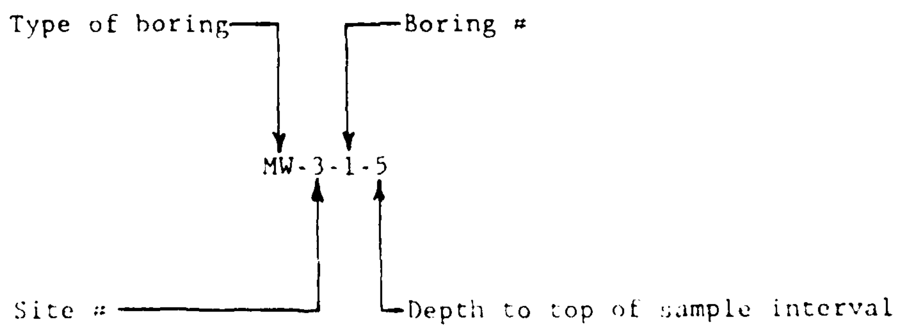
Elevation refers to the elevation to the top of the sample interval measured in feet above mean sea level (MSL).

LITHOLOGIC SYMBOLS

The lithologic symbols provide a visual description of the type of soil collected in the sample interval. The lithologic symbols are keyed to the specific soil types. For key symbols, refer to the following discussion on soil types.

LAB SAMPLE NUMBER

The sample numbering identifies four characteristics of the sample:



For example, sample number MW-3-1-5 was collected at monitoring well 1, Site 3, at a depth of 5 feet.

BLOW COUNT

The blow count indicates the number of blows required for a 40 lb hammer to drive a split-spoon sampler 24 inches. The blows are counted every 6 inches to provide an indication of the density of the subsurface material.

TOP OF SAMPLE

The top of sample indicates the depth below land surface (BLS) of the top of the interval sampled by the split-spoon sampling device.

RECOVERY

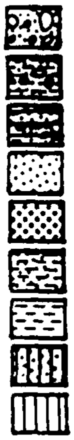
The recovery is a measurement of the amount of material retained by the 2.0 foot split-spoon sampler. In cases where no sample was retained by the split-spoon sampler, "No Recovery" was indicated on the boring log. Also, where samples were not collected with split-spoon sampler, the recovery measurement was not possible.

HNu

The HNu gives the value of organic vapor content of the sample measured in parts per million (PPM) by a HNu photoionization detector. The NR flag which appears in this column indicates that both of the HNu meters were malfunctioning during the well logging process, therefore no readings were recorded.

SOIL TYPE

Soil types are identified based on the Unified Soil Classification System (USCS). The following USCS abbreviations and lithologic symbols were used for soil type identifications:



GW - pebbly gravels; coarse sands, little or no fines
GP - gravel, gravel-sand mixtures, little or no fines
GM - silty gravel, gravel-sand-silt mixtures
SW - well graded sands, gravelly sands, little or no fines
SP - poorly graded sands, gravelly sands, little or no fines
SM - silty sands, sand-silt mixtures
ML - silts and very fine sands
SC - clayey sands, sand clay mixtures
CL - inorganic clay

LITHOLOGIC DESCRIPTION

The types of lithologic characteristics described in the boring logs are identified below:

- lithology
- grain size
- sorting
- roundness/sphericity
- density
- plasticity
- wetness
- color
- Munsell color system number
- other distinguishing characteristics

Lithology

The lithology of the sample refers to the specific type of material of which the sample is composed (i.e., gravel, sand, silt, or clay).

Grain Size

The grain size of the sample refers to the degree of coarseness of the particles in each lithologic category (i.e., very fine to very coarse).

Sorting

Sorting is a measure of the homogeneity of the size of grains within the soil sample. A well sorted sample is homogeneous with respect to grain size, while a poorly sorted sample is heterogeneous.

Roundness/Sphericity

The degree of roundness/sphericity of the grains within the samples were identified using the following:

- subdiscoidal
- spherical
- subprismoidal
- prismoidal
- rounded
- subrounded
- subangular
- angular

Density

Descriptions referring to density indicate the condition of the split-spoon soil sample and do not necessarily reflect the conditions of the subsurface

materials as indicated by blow counts. The density of the split-spoon samples was described using the following terms:

- For sand and silt samples:
  - loose
  - medium
  - dense

- For clay samples:
  - soft
  - stiff
  - hard

<u>Plasticity</u>

Plasticity of soils refers to the ability of the soil to be deformed without breaking up and to maintain the new shape after the deforming force has been released. Soil samples were classified as being either non-plastic, slightly plastic, or plastic.

<u>Wetness</u>

The degree of wetness in the soil samples was described as follows:

- dry
- moist
- wet

<u>Color</u>

Colors of soil samples were identified using the Munsell system of color notations. Colors were identified by both name and number in order to provide a precise reference point for the actual soil color.

Other Distinguishing Characteristics

In addition to the previously mentioned categories of sample description, any additional unusual or distinguishing characteristics of the sample were provided.

ADDITIONAL SYMBOLS ON MONITORING WELL BOREHOLE LOGS

- ☰ Indicates the screened interval of the monitoring well
- ▼ Indicates the static groundwater level within the well on May 3, 1989, unless otherwise noted.

SITE 1-UNDERGROUND FUEL STORAGE AREA

SOIL BORING NO.	B1-1	JOE FOSS FIELD	DRILLING COMPANY	LAYNE-WESTERN
SUPERVISORY GEOLOGIST	D. VANWINKLE	SOIL BORING LOG	RIG TYPE	HOLLOW-STEM AUGER
LOG BOOK/PG No.	2/5-6			
DRILLING STARTED	4/11/89			
ABANDONMENT COMPLETED	4/12/89			

DEPTH (BLS)	LITHOLOGIC SYMBOLS	LAB SAMPLE NUMBER	BLOW COUNT	TOP OF SAMPLE ('BLS)	RECOVERY	HNU	SOIL TYPE (USCS)	LITHOLOGIC DESCRIPTION
0.0								
5.0			8:8:10:12	5.0	1.3	NR	SC(60%)	COARSE CLAYEY SAND, trace pebbles; poorly sorted; subangular to subround; spherical; soft; plastic; moist; very dark grayish brown, (10YR3/2).
							CL(40%)	CLAY; soft; plastic; moist; black, (5Y 2.5/1)
10.0			5:10:16:20	10.0	1.7	NR	SC(50%)	COARSE CLAYEY SAND; poorly sorted; subangular to subround; spherical; soft; slightly plastic; moist; very dark grayish brown (10YR 3/2); hydrocarbon odor.
							SP(50%)	FINE TO MEDIUM SAND, trace pebbles; well sorted; subangular to subround; spherical; loose; non-plastic; moist; dark gray, (5Y 4/1); hydrocarbon odor.
15.0		B1-1-15	9:12:18:22	15.0	1.8	NR	SP	COARSE SAND; well sorted; subround to round; spherical, trace prismoidal, trace discoidal; loose; non-plastic; wet; gray, (5Y 5/1), hydrocarbon odor.
20.0			10:10:10:6	20.0	1.4	NR	SW	MEDIUM TO VERY COARSE SAND, trace pebbles to cobbles; very poorly sorted; subround to round; spherical, trace subdiscoidal; loose; non-plastic; saturated; gray, (5Y 5/1); hydrocarbon odor.
25.0		B1-1-25	high	25.0	1.4	NR	SW	COARSE TO VERY COARSE SAND, trace pebbles; very poorly sorted; subround to round; spherical; loose; non-plastic; saturated; gray, (5Y 5/1); hydrocarbon odor.
30.0			high	30.0	0.8	NR	SW	MEDIUM TO COARSE SAND, trace fine pebbles; moderately sorted; subround to round; spherical, trace prismoidal, trace didscoidal; loose; non-plastic; saturated; gray, (5Y 5/1); hydrocarbon odor.
35.0			7:29:23:10	35.0	2.0	NR	SW	MEDIUM TO VERY COARSE SAND, trace fine pebbles; poorly sorted; round; spherical, trace prismoidal, trace discoidal; loose; non-plastic; saturated; gray, (5Y 5/1); hydrocarbon odor.
40.0			20:15:11:17	40.0	2.0	NR	SP(50%)	MEDIUM SAND; well sorted; subround to round; spherical, trace prismoidal, trace discoidal; loose; non-plastic; wet; gray (5Y 5/1); hydrocarbon odor.
							CL(50%)	CLAY, trace pebbles, cobbles; poorly sorted; verty stiff; plastic; moist dark gray (5Y 4/1); glacial till.
45.0			10:10:16:22	45.0	2.0	NR	CL	CLAY, trace pebbles to cobbles; poorly sorted; very stiff; plastic; moist; dark gray, (5Y 4/1); glacial till.
50.0			NR	50.0	2.0	NR	CL	CLAY; trace very coarse sand to fine pebbles; poorly sorted; very stiff; slightly plastic; moist; dark gray, (5Y 4/1); glacial till.

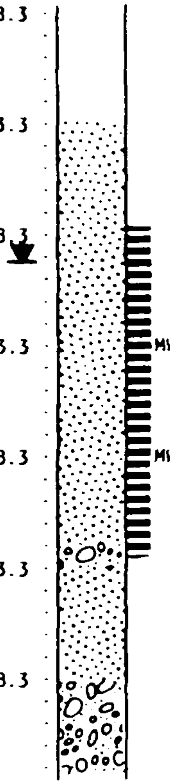
NR-Not Recorded

SOIL BORING NO.	B1-2	JOE FOSS FIELD		DRILLING COMPANY	LAYNE-WESTERN
SUPERVISORY GEOLOGIST	D. VANWINKLE	SOIL BORING LOG		RIG TYPE	HOLLOW-STEM AUGER
LOG BOOK/PG No.	2/7-8				
DRILLING STARTED	4/12/89				
ABANDONMENT COMPLETED	4-13-89				

DEPTH (BLS)	LITHOLOGIC SYMBOLS	LAB SAMPLE NUMBER	BLOW COUNT	TOP OF SAMPLE ('BLS)	RECOVERY	HNU	SOIL TYPE (USCS)	LITHOLOGIC DESCRIPTION
0.0								
5.0			4:5:8:11	5.0	1.7	NR	ML(60%)	SILTY CLAY, trace medium to coarse sand; moderately sorted; soft; plastic; moist; very dark grayish brown, (10YR 3/2); trace organic material.
							SP(40%)	MEDIUM SAND; well sorted; subround to round; spherical, trace prismoidal; loose; non-plastic; moist; pale brown to light yellowish brown, (10YR 6/3.5).
10.0			4:10:17:13	10.0	1.3	NR	SW	MEDIUM TO VERY COARSE SAND, trace pebbles, trace cobbles; poorly sorted; subround to round; spherical, trace subprismoidal; loose; non-plastic; moist; brown, (10YR 4.5/3) (Water encountered at approximately 12 feet BLS)
15.0		B1-2-15	6:8:12:14	15.0	1.1	NR	SW	MEDIUM TO COARSE SAND, some very coarse sand to fine pebbly gravel, trace cobbles; poorly sorted; subround to round; spherical, trace prismoidal, trace discoidal; loose; non-plastic; saturated; gray, (7.5Y 5/0); hydrocarbon odor.
20.0			5:20:50:25	20.0	1.5	NR	SW	VERY COARSE SAND, some pebbles, trace cobbles; very poorly sorted; spherical, some discoidal, trace prismoidal; loose; non-plastic; saturated; gray, (5Y 5/1); hydrocarbon odor.
25.0		B1-2-25	54:100:79:5	25.0	1.7	NR	SW(90%)	COARSE TO VERY COARSE SAND, trace fine pebbles to cobbles; very poorly sorted; subround to round; spherical, some discoidal, trace prismoidal; loose; non-plastic; saturated; gray to dark gray, (5Y 4.5/1); hydrocarbon odor.
							CL(10%)	CLAY; soft; plastic; wet; very dark grayish brown.
30.0			25:36:14:24	30.0	1.9	NR	SW(95%)	COARSE TO VERY COARSE SAND, some pebbles to cobbles; very poorly sorted; subround to round; spherical, some discoidal, trace prismoidal; loose; non-plastic; saturated; gray, (5Y 5/1); hydrocarbon odor.
							CL(5%)	CLAY, trace coarse sand to medium pebbly gravel; poorly sorted; firm; slightly plastic; moist; dark gray, (5Y 4/1); Glacial till (bottom 0.2 ft spoon).
35.0			25:54:65:69	35.0	2.0	NR	SW(95%)	COARSE SAND, trace pebbly gravel; moderately sorted; subround to round; spherical, trace subdiscoidal; loose; non-plastic; saturated; light brownish gray, (2.5Y 6/2); slight hydrocarbon odor.
							CL(5%)	CLAY, trace coarse sand to pebbly gravel; poorly sorted; stiff; slightly plastic; moist; dark gray, (2.5Y 5/2); Glacial till (bottom 0.2 feet of spoon).
40.0		B1-2-42*	6:10:10:20:	40.0	2.0	NR	CL(95%)	CLAY, trace coarse sand, trace fine pebbles; poorly sorted; very stiff; slightly plastic; moist; dark grayish brown, (2.5Y 5/2); Glacial till.
							SP(5%)	COARSE SAND, traces fine pebbly gravel; well sorted; subround to round; spherical, loose; non-plastic; wet; grayish brown, (2.5Y 5/2); small band in center of spoon.

NR-Not Recorded
*-Geotechnical Sample

MONITORING WELL BORING NO.	MW1-5	JOE FOSS FIELD	DRILLING COMPANY: LAYNE-WESTERN
SUPERVISORY GEOLOGIST	D. VANWINKLE	MONITORING WELL LOG	RIG TYPE: HOLLOW-STEM AUGER
LOG BOOK/PG No.	2/19-21		
DRILLING STARTED	4-16-89		
COMPLETION DATE	4-25-89		



DEPTH (BLS)	ELEV (MSL)	LITHOLOGIC SYMBOLS	LAB SAMPLE NUMBER	BLOW COUNT	TOP OF SAMPLE ('BLS)	RECOVERY (feet)	HNU	SOIL TYPE (USCS)	LITHOLOGIC DESCRIPTION
0.0	1418.3								
5.0	1413.3			12:21:22:20	5.0	1.6	0.5	SW	MEDIUM TO COARSE SAND, some fine pebbles, trace medium pebbles; poorly sorted; subround to round; spherical, trace subdiscoidal; loose; non-plastic; moist; light olive brown, (2.5Y 5/6).
10.0	1408.3			10:13:14:13	10.0	1.3	0.5	SW	VERY COARSE SAND, some fine to medium pebbles; very poorly sorted; subround to round; spherical, trace discoidal; loose; non-plastic; saturated; dark grayish brown, (2.5Y 4/2); water encountered at approximately 11 feet BLS.
15.0	1403.3		MW1-5-15	1:4:8:17	15.0	1.3	0.5	SW	VERY COARSE SAND, some fine to medium pebbles; very poorly sorted; subround to round; spherical, trace discoidal; loose; non-plastic; saturated; gray, (5Y 5/1).
20.0	1398.3		MW1-5-20	3:4:9:16	20.0	1.1	0.5	SW(90%)	VERY COARSE SAND, some fine to medium pebbles; very poorly sorted; subround to round; spherical, trace discoidal; loose; non-plastic; saturated; gray, (5Y 5/1).
								GW(10%)	FINE TO MEDIUM PEBBLY GRAVEL, trace coarse sand; subround to round; spherical, trace discoidal; loose; non-plastic; saturated; light gray to gray, (5Y 5.5/1).
25.0	1393.3			13:19:24:18	25.0	1.7	0.5	SW	VERY COARSE SAND, some fine to medium pebbles; very poorly sorted; subround to round; spherical, trace discoidal; loose; non-plastic; saturated; gray, (5Y 5/1).
30.0	1388.3			10:10:13:9	30.0	1.5	0.5	GW	FINE TO MEDIUM PEBBLY GRAVEL, some coarse sand, trace fine sand; very poorly sorted; subround to round; spherical, trace discoidal; loose; non-plastic; saturated; gray to dark gray, (5Y 4.5/1).

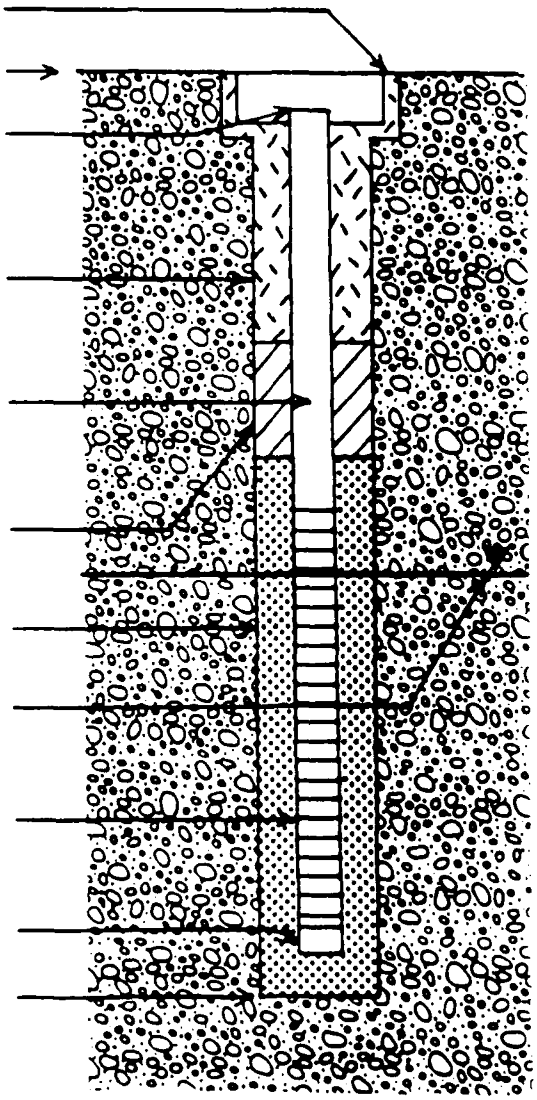
MONITORING WELL CONSTRUCTION SUMMARY

Well No.	:	MW-1-5
Location (SD Coord.)		
Northings	:	471,831.1
Eastings	:	2,953,310.6
Reference Point	:	TOP OF PVC CASING
Reference Point Elev.	:	1418.28 MSL
Type of Security	:	VAULT
Supervisory Geologist	:	D. VanWINKLE
Log Book/Page No.	:	2/19-21
Drilling Company	:	LAYNE (OMAHA)
Rig Type	:	HOLLOW-STEM AUGER
Driller	:	L. HRABIK
Drilling Started	:	4/16/89 0800
Drilling Completed	:	4/16/89 1300

Development		
Date	:	4/27/89
Type	:	PUMPING
Volume Purged	:	1242 GALLONS
Water Level/Date:		1407.19 MSL-5/3/89

MONITORING WELL AS-BUILT

		BLS	MSL
Watertight Vault			
Land Surface		0.0	1418.3
Top of PVC Flush Joint Riser w/Locking PVC Cap		0.0	1418.28
Cement/Bentonite Grout	Top	1.0	1417.3
	Bottom	7.6	1410.7
4" I.D. Schedule 40 PVC Flush Joint Riser	Top	0.0	1418.3
	Bottom	9.4	1408.9
Bentonite 1/4" Pellet Seal	Top	7.6	1410.7
	Bottom	9.1	1409.2
Sand Pack	Top	9.1	1409.2
	Bottom	30.0	1388.3
Static Water Level	5/03/89	11.09	1407.19
4" I.D. Schedule 40 PVC Flush Joint Screen 0.040" Slot 4 Slots/Inch	Top	9.4	1408.9
	Bottom	24.4	1393.9
Bottom Plug		24.9	1393.4
12" Borehole Total Depth		30.0	1388.3

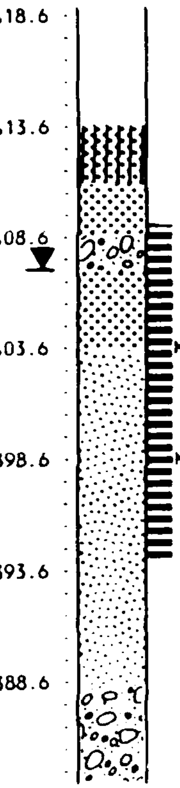


NOT TO SCALE

All measurements in feet unless otherwise noted
BLS - Below Land Surface
MSL - Mean Sea Level Datum

MONITORING WELL BORING NO.	MW1-6	JOE FOSS FIELD	DRILLING COMPANY: LAYNE-WESTERN
SUPERVISORY GEOLOGIST	D. VANWINKLE	MONITORING WELL LOG	RIG TYPE: HOLLOW-STEM AUGER
LOG BOOK/PG No.	2/22-23		
DRILLING STARTED	4/16/89		
COMPLETION DATE	4-25-89		

LITHOLOGIC SYMBOLS



DEPTH (BLS)	ELEV (MSL)	LAB SAMPLE NUMBER	BLOW COUNT	TOP OF SAMPLE ('BLS)	RECOVERY (feet)	HNU	SOIL TYPE (USCS)	LITHOLOGIC DESCRIPTION
0.0	1418.6							
5.0	1413.6		4:7:4:7	5.0	1.4	0.2	SC(50%)	CLAYEY SAND; well sorted; subround to round; spherical, trace discoidal; soft; plastic; moist; gray, (5Y 5/1).
							SP(50%)	COARSE SAND; well sorted; subround to round; spherical; loose; non-plastic moist; (2.5Y 5/2)
10.0	1408.6		11:19:17:18	10.0	1.0	0.2	GW(30%)	FINE TO MEDIUM PEBBLY GRAVEL; very poorly sorted; subround to round; spherical, trace discoidal; loose; non-plastic; moist; dark grayish brown to olive gray (2.5Y 4/3).
							SP(70%)	COARSE SAND; well sorted; subround to round; spherical; loose; non-plastic; moist; dark grayish brown to olive brown, (2.5Y 4/3); water encountered 12 feet BLS.
15.0	1403.6	MW1-6-15	7:15:22:25	15.0	2.0	0.2	SW	VERY COARSE SAND, trace fine to medium pebbles; poorly sorted; spherical, trace discoidal; loose; non-plastic; saturated; top 40% - brownish gray to dark brownish gray (2.5Y 4.5/2), bottom 60% - dark gray (5Y 4/1); hydrocarbon odor.
20.0	1398.6	MW1-6-20	8:8:6:12	20.0	1.6	0.2	SW	VERY COARSE SAND, some fine to medium pebbles; poorly sorted; subround to round spherical, trace discoidal; loose; non-plastic; saturated; brownish gray to dark brownish gray, (2.5Y 4.5/2); hydrocarbon odor.
25.0	1393.6		8:9:8:10	25.0	2.0	0.2	SW	VERY COARSE SAND, some fine to medium pebbles; poorly sorted; subround to round spherical, trace discoidal; loose; non-plastic; saturated; dark gray, (5Y 4/1); slight hydrocarbon odor.
30.0	1388.6		9:22:42:65	30.0	1.5	0.2	GW	FINE TO MEDIUM PEBBLY GRAVEL, some very coarse sand; very poorly sorted subround to round; spherical, trace discoidal; loose; non-plastic; saturated; gray to dark gray, (5Y 4.5/1).

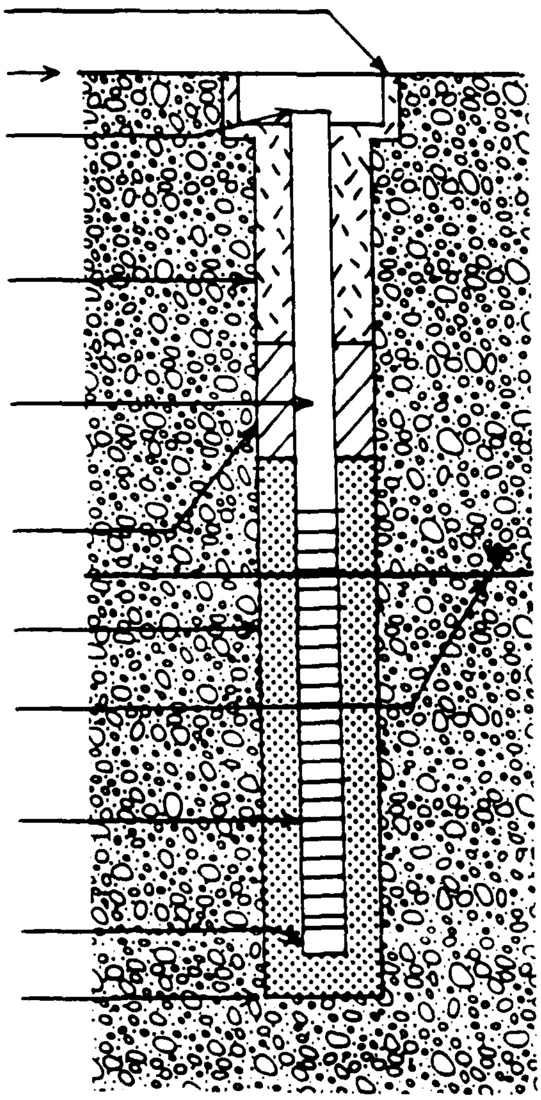
MONITORING WELL CONSTRUCTION SUMMARY

Well No.	: MW-1-6	Development		
Location (SD Coord.)		Date	:	4/27/89
Northings	: 471,927.6	Type	:	PUMPING
Eastings	: 2,953,234.0	Volume Purged	:	1196 GALLONS
Reference Point	: TOP OF PVC CASING			
Reference Point Elev.	: 1418.63 MSL	Water Level/Date:		1407.13 MSL-5/3/89
Type of Security	: VAULT			

Supervisory Geologist	: D. VanWINKLE
Log Book/Page No.	: 2/22-23
Drilling Company	: LAYNE (OMAHA)
Rig Type	: HOLLOW-STEM AUGER
Driller	: L. HRABIK
Drilling Started	: 4/16/89 1300
Drilling Completed	: 4/16/89 1900

MONITORING WELL AS-BUILT

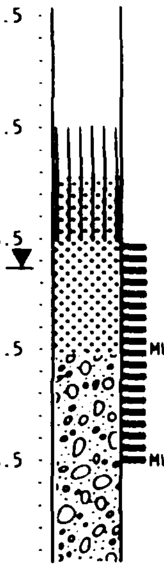
		BLS	MSL
Watertight Vault			
Land Surface		0.0	1418.6
Top of PVC Flush Joint Riser w/Locking PVC Cap		0.0	1418.63
Cement/Bentonite Grout	Top	1.0	1417.6
	Bottom	4.5	1414.1
4" I.D. Schedule 40 PVC Flush Joint Riser	Top	0.0	1418.6
	Bottom	9.2	1409.4
Bentonite 1/4" Pellet Seal	Top	4.5	1414.1
	Bottom	5.9	1412.7
Sand Pack	Top	5.9	1412.7
	Bottom	30.0	1388.6
Static Water Level	5/03/89	11.50	1407.13
4" I.D. Schedule 40 PVC Flush Joint Screen 0.040" Slot 4 Slots/Inch	Top	9.2	1409.4
	Bottom	24.2	1394.4
Bottom Plug		24.7	1393.9
12" Borehole Total Depth		30.0	1388.6



NOT TO SCALE

All measurements in feet unless otherwise noted
BLS - Below Land Surface
MSL - Mean Sea Level Datum

MONITORING WELL BORING NO.	MW1-7	JOE FOSS FIELD	DRILLING COMPANY: LAYNE-WESTERN
SUPERVISORY GEOLOGIST	D. VANWINKLE	MONITORING WELL LOG	RIG TYPE: HOLLOW-STEM AUGER
LOG BOOK/PG No.	2/24-25,35		
DRILLING STARTED	4-17-89		
COMPLETION DATE	4-28-89		



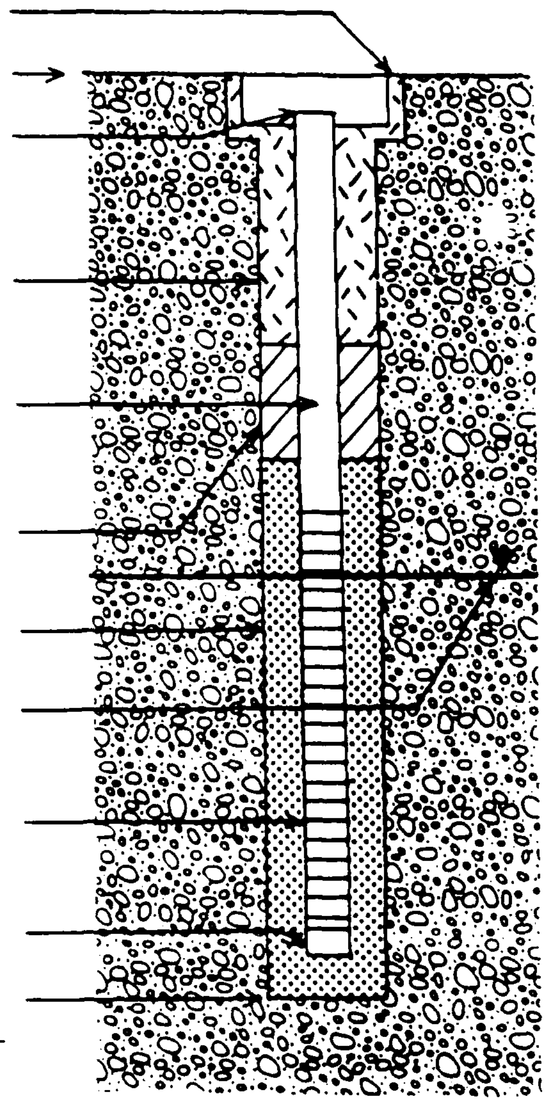
DEPTH (BLS)	ELEV (MSL)	LITHOLOGIC SYMBOLS	LAB SAMPLE NUMBER	BLOW COUNT	TOP OF SAMPLE ('BLS)	RECOVERY (feet)	HNU	SOIL TYPE (USCS)	LITHOLOGIC DESCRIPTION
0.0	1418.5								
5.0	1413.5			5:12:9:12	5.0	1.5	0.2	CL(40%)	SANDY CLAY; moderately sorted; subround to round; spherical; soft; plastic; moist; very dark gray, (2.5Y 3/2).
								SC(60%)	CLAYEY SAND; well sorted; subround to round; spherical; loose; non-plastic; moist; grayish brown to dark grayish brown, (2.5Y 4.5/2).
10.0	1408.5			13:19:16:13	10.0	1.4	0.2	SP	COARSE TO VERY COARSE SAND, trace fine pebbles; well sorted; subround to round; spherical, trace discoidal; loose; non-plastic; moist (saturated bottom 0.5 feet); grayish brown to brown, (10YR 5/2.5) grading to dark grayish brown, (2.5Y 4/2). Water encountered at approximately 11.5 feet BLS.
15.0	1403.5		MW1-7-15	2:12:11:15	15.0	1.1	0.2	GW	FINE TO MEDIUM PEBBLY GRAVEL, some very coarse sand; very poorly sorted; subangular to round; spherical, some discoidal; loose; non-plastic; saturated; grayish brown, (2.5Y 5/2).
20.0	1398.5		MW1-7-20	6:8:7:8	20.0	1.6	0.2	GW	FINE TO MEDIUM PEBBLY GRAVEL, some very coarse sand; very poorly sorted; subangular to round; spherical, some discoidal; loose; non-plastic; saturated; grayish brown, (2.5Y 5/2).

MONITORING WELL CONSTRUCTION SUMMARY

Well No.	:	MW-1-7	Development	
Location (SD Coord.)			Date	: 4/28/89
Northings	:	471,785.5	Type	: PUMPING
Eastings	:	2,953,161.7	Volume Purged	: 1150 GALLONS
Reference Point	:	TOP OF PVC CASING		
Reference Point Elev.	:	1418.50 MSL	Water Level/Date:	1407.14 MSL-5/3/89
Type of Security	:	VAULT		
Supervisory Geologist	:	D. VanWINKLE		
Log Book/Page No.	:	2/24-25		
Drilling Company	:	LAYNE (OMAHA)		
Rig Type	:	HOLLOW-STEM AUGER		
Driller	:	L. HRABIK		
Drilling Started	:	4/17/89 0700		
Drilling Completed	:	4/17/89 1045		

MONITORING WELL AS-BUILT

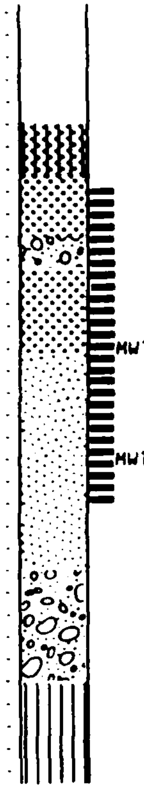
		BLS	MSL
Watertight Vault			
Land Surface		0.0	1418.5
Top of PVC Flush Joint Riser w/Locking PVC Cap		0.0	1418.50
Cement/Bentonite Grout	Top	1.0	1417.5
	Bottom	4.0	1414.5
4" I.D. Schedule 40 PVC Flush Joint Riser	Top	0.0	1418.5
	Bottom	10.1	1408.4
Bentonite 1/4" Pellet Seal	Top	4.0	1414.5
	Bottom	6.1	1412.4
Sand Pack	Top	6.1	1412.4
	Bottom	23.0	1395.5
Static Water Level	5/03/89	11.36	1407.14
4" I.D. Schedule 40 PVC Flush Joint Screen 0.040" Slot 4 Slots/Inch	Top	10.1	1408.4
	Bottom	20.1	1398.4
Bottom Plug		20.6	1397.9
12" Borehole Total Depth		23.0	1395.5



NOT TO SCALE

All measurements in feet unless otherwise noted
BLS - Below Land Surface
MSL - Mean Sea Level Datum

MONITORING WELL BORING NO.	MW1-8	JOE FOSS FIELD	DRILLING COMPANY LAYNE-WESTERN
SUPERVISORY GEOLOGIST	D. VANWINKLE	MONITORING WELL LOG	RIG TYPE HOLLOW-STEM AUGER
LOG BOOK/PG No.	2/24,27		
DRILLING STARTED	4/17/89		
COMPLETION DATE	4-26-89		



DEPTH (BLS)	ELEV (MSL)	LAB SAMPLE NUMBER	BLOW COUNT	TOP OF SAMPLE ('BLS)	RECOVERY (feet)	HNU (PPM)	SOIL TYPE (USCS)	LITHOLOGIC DESCRIPTION
0.0	1418.6							
5.0	1413.6		5:4:5:11	5.0	1.5	0.2	SC(50%)	CLAYEY SAND; well sorted; subround to round; spherical, trace discoidal; soft; plastic; moist; gray, (5Y 5/1).
							SP(50%)	COARSE SAND; well sorted; subround to round; spherical; loose; non-plastic moist; (2.5Y 5/3).
10.0	1408.6		7:7:13:15	10.0	1.5	60.0	GW(30%)	FINE TO MEDIUM PEBBLY GRAVEL; very poorly sorted; subround to round; spherical, trace discoidal; loose; non-plastic; moist; dark grayish brown to olive gray (2.5Y 4/3).
							SP(70%)	COARSE SAND; well sorted; subround to round; spherical; loose; non-plastic; moist; dark grayish brown to olive brown, (2.5Y 4/3); water encountered 12 feet BLS.
15.0	1403.6	MW1-8-15	3:13:15:14	15.0	1.4	110	SW	VERY COARSE SAND, trace fine to medium pebbles; poorly sorted; spherical, trace discoidal; loose; non-plastic; saturated; top 40% - brownish gray to dark brownish gray (2.5Y 4.5/2), bottom 60% - dark gray (5Y 4/1); hydrocarbon odor.
20.0	1398.6	MW1-8-20	9:2:4:2	20.0	1.7	130	SW	FINE TO MEDIUM PEBBLY GRAVEL, some cobbles; very poorly sorted; subround to round; spherical, trace discoidal; loose; non-plastic; saturated; dark gray, (5Y 4/1).
25.0	1393.6		11:12:13:14	25.0	2.0	8.0	GW	FINE TO MEDIUM PEBBLY GRAVEL, some cobbles; very poorly sorted; subround to round; spherical, trace discoidal; loose; non-plastic; saturated; dark gray, (5Y 4/1).
30.0	1388.6		9:16:31:41	30.0	1.7	NR	CL	CLAY, trace fine to medium pebbles; poorly sorted; very stiff; slightly plastic; moist; gray to dark gray, (5Y 4.5/1); glacial till.

NR Not Recorded

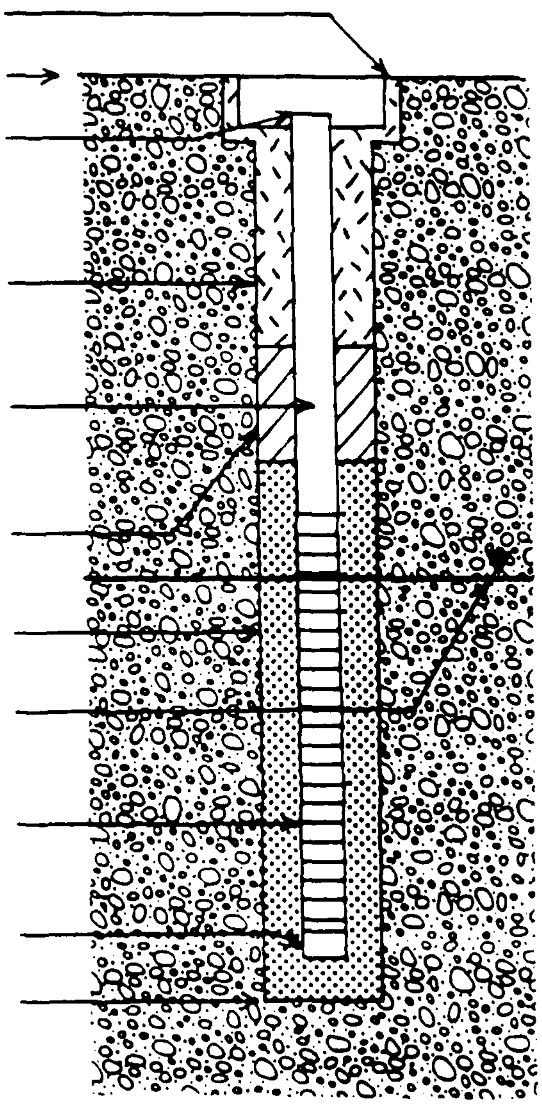
MONITORING WELL CONSTRUCTION SUMMARY

Well No.	: MW-1-8	Development		
Location (SD Coord.)		Date	:	4/27/89
Northings	: 472,016.2	Type	:	PUMPING
Eastings	: 2,953,186.9	Volume Purged	:	1265 GALLONS
Reference Point	: TOP OF PVC CASING			
Reference Point Elev.	: 1418.33 MSL	Water Level/Date:		1407.10 MSL-5/3/89
Type of Security	: VAULT			

Supervisory Geologist	: D. VanWINKLE
Log Book/Page No.	: 2/24-27
Drilling Company	: LAYNE (OMAHA)
Rig Type	: HOLLOW-STEM AUGER
Driller	: L. HRABIK
Drilling Started	: 4/17/89 1045
Drilling Completed	: 4/17/89 1900

MONITORING WELL AS-BUILT

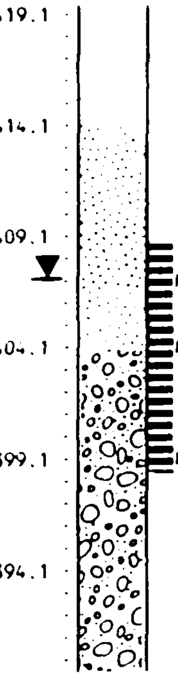
		BLS	MSL
Watertight Vault			
Land Surface		0.0	1418.6
Top of PVC Flush Joint Riser w/Locking PVC Cap		0.3	1418.33
Cement/Bentonite Grout	Top	1.0	1417.6
	Bottom	3.3	1415.3
4" I.D. Schedule 40 PVC Flush Joint Riser	Top	0.3	1418.3
	Bottom	7.9	1410.7
Bentonite 1/4" Pellet Seal	Top	3.3	1415.3
	Bottom	5.3	1413.3
Sand Pack	Top	5.3	1413.3
	Bottom	30.0	1388.6
Static Water Level	5/03/89	11.48	1407.10
4" I.D. Schedule 40 PVC Flush Joint Screen 0.040" Slot 4 Slots/Inch	Top	7.9	1410.7
	Bottom	27.9	1390.7
Bottom Plug		28.4	1390.2
12" Borehole Total Depth		30.0	1388.6



NOT TO SCALE

All measurements in feet unless otherwise noted
BLS - Below Land Surface
MSL - Mean Sea Level Datum

MONITORING WELL BORING NO.	MW1-9	JOE FOSS FIELD	DRILLING COMPANY: LAYNE-WESTERN
SUPERVISORY GEOLOGIST	D. VANWINKLE	MONITORING WELL LOG	RIG TYPE: HOLLOW-STEM AUGER
LOG BOOK/PG No.	2/39-40,43-44		
DRILLING STARTED	4-25-89		
COMPLETION DATE	4-26-89		



DEPTH (BLS)	ELEV (MSL)	LAB SAMPLE NUMBER	BLOW COUNT	TOP OF SAMPLE ('BLS)	RECOVERY (feet)	HNU (PPM)	SOIL TYPE (USCS)	LITHOLOGIC DESCRIPTION
0.0	1419.1							
5.0	1414.1		10:24:25:28	5.0	1.4	0.2	SW	COARSE TO VERY COARSE SAND, some fine to medium pebbles; very poorly sorted; subround to round; spherical, trace discoidal; loose; non-plastic; moist; light yellowish brown, (10YR 6/4).
10.0	1409.1	MW1-9-12*	6:7:11:13	10.0	1.5	0.2	SW	MEDIUM TO COARSE SAND, trace fine to medium pebbles, trace bituminous coal; poorly to moderately sorted; subround to round; spherical, trace discoidal; loose; non-plastic; wet; grayish brown to dark grayish brown, (10YR 4.5/2); water encountered approx. 11.5 feet BLS.
15.0	1404.1	MW1-9-15	6:13:19:21	15.0	1.5	0.2	GW	FINE TO MEDIUM PEBBLY GRAVEL, some very coarse sand; very poorly sorted; subround to round; spherical, some discoidal; loose; non-plastic; saturated; grayish brown to dark grayish brown, (10YR 4.5/2).
20.0	1399.1	MW1-9-20	4:4:6:9	20.0	1.1	0.2	GW	FINE TO MEDIUM PEBBLY GRAVEL, some cobbles, some very coarse sand; very poorly sorted; subround to round; spherical, some discoidal; loose; non-plastic; saturated; grayish brown to dark grayish brown, (10YR 4.5/2).
25.0	1394.1		8:12:7:7	25.0	1.0	0.2	GW	FINE TO MEDIUM PEBBLY GRAVEL, some very coarse sand, trace cobbles, boulders; very poorly sorted; subround to round; spherical, some discoidal; loose; non-plastic; saturated; grayish brown to dark grayish brown, (10YR 4.5/2).

* Geotechnical sample

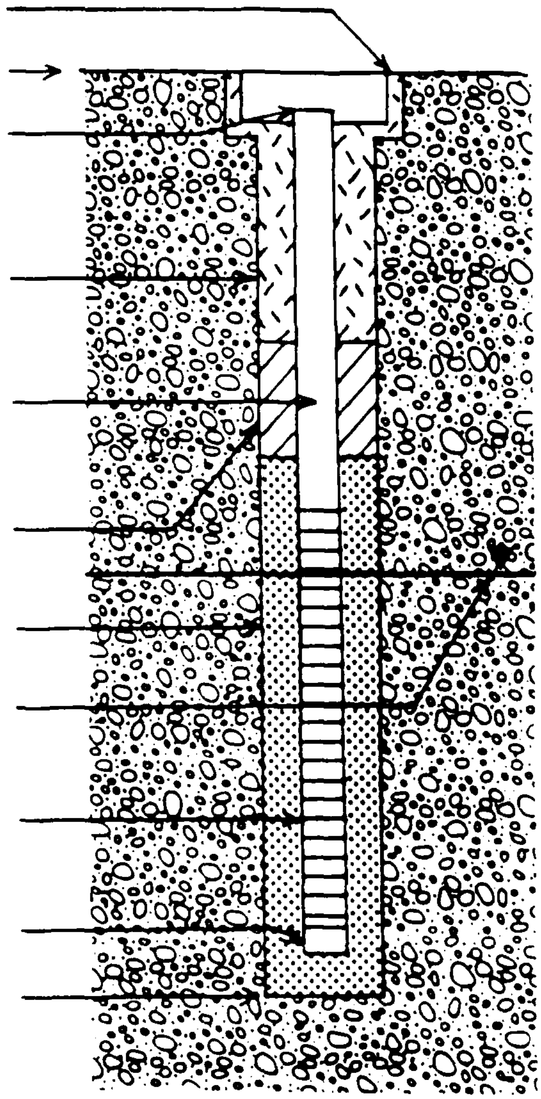
MONITORING WELL CONSTRUCTION SUMMARY

Well No.	:	MW-1-9	Development		
Location (SD Coord.)			Date	:	4/26/89
Northings	:	471,861.1	Type	:	PUMPING
Eastings	:	2,953,449.9	Volume Purged	:	1173 GALLONS
Reference Point	:	TOP OF PVC CASING			
Reference Point Elev.	:	1418.76 MSL	Water Level/Date:		1407.21 MSL-5/3/89
Type of Security	:	VAULT			

Supervisory Geologist	:	D. VanWINKLE
Log Book/Page No.	:	2/39-40
Drilling Company	:	LAYNE (OMAHA)
Rig Type	:	HOLLOW-STEM AUGER
Driller	:	L. HRABIK
Drilling Started	:	4/25/89 0700
Drilling Completed	:	4/25/89 1215

MONITORING WELL AS-BUILT

		BLS	MSL
Watertight Vault			
Land Surface		0.0	1419.1
Top of PVC Flush Joint Riser w/Locking PVC Cap		0.3	1418.76
Cement/Bentonite Grout	Top	1.0	1418.1
	Bottom	5.0	1414.1
4" I.D. Schedule 40 PVC Flush Joint Riser	Top	0.3	1418.8
	Bottom	10.3	1408.8
Bentonite 1/4" Pellet Seal	Top	5.0	1414.1
	Bottom	6.8	1412.3
Sand Pack	Top	6.8	1412.3
	Bottom	25.0	1394.1
Static Water Level	5/03/89	11.85	1407.21
4" I.D. Schedule 40 PVC Flush Joint Screen 0.040" Slot 4 Slots/Inch	Top	10.3	1408.8
	Bottom	20.3	1398.8
Bottom Plug		20.8	1398.3
12" Borehole Total Depth		25.0	1394.1



NOT TO SCALE

All measurements in feet unless otherwise noted
BLS - Below Land Surface
MSL - Mean Sea Level Datum

MONITORING WELL BORING NO.	MW1 10	JOE FOSS FIELD	
SUPERVISORY GEOLOGIST	D. VANWINKLE	MONITORING WELL LOG	
LOG BOOK/PG No.	2/43,47-48	DRILLING COMPANY	LAYNE-WESTERN
DRILLING STARTED	4-26-89	RIG TYPE	HOLLOW-STEM AUGER
COMPLETION DATE	4-26-89		

DEPTH (BLS)	ELEV (MSL)	LITHOLOGIC SYMBOLS	LAB SAMPLE NUMBER	BLOW COUNT	TOP OF SAMPLE ('BLS)	RECOVERY (feet)	HNU (PPM)	SOIL TYPE (USCS)	LITHOLOGIC DESCRIPTION
0.0	1419.0								
5.0	1414.0			8:15:19:27	5.0	1.7	NR	SW	VERY COARSE SAND, some fine to medium pebbles, trace layered silt; very poorly sorted; subangular to round; spherical, some discoidal, trace prismoidal; loose; non-plastic; moist; light olive brown, (2.5Y 5/4).
10.0	1409.0			10:16:17:22	10.0	1.7	NR	SP(50%)	MEDIUM SAND; well sorted; subround to round; spherical; loose; non-plastic; moist; light gray to gray, (2.5Y 5.5/2).
								SW(50%)	COARSE TO VERY COARSE SAND, trace fine pebbles; poorly sorted; subround to round; spherical, trace discoidal, prismoidal; loose; non-plastic; saturated; dark grayish brown, (2.5Y 4/2); water encountered approx. 11 feet BLS.
15.0	1404.0		MW1 10-15	5:16:22:23	15.0	1.6	NR	GW	FINE TO MEDIUM PEBBLEY GRAVE', some medium to coarse sand; very poorly sorted; subround to round; spherical, some discoidal; loose; non-plastic; saturated; dark grayish brown, (2.5Y 4/2).
20.0	1399.0		MW1 10-20	11:14:25:30	20.0	1.7	NR	SW	VERY COARSE SAND, some fine to medium pebbles; very poorly sorted; subround to round; spherical, some discoidal; loose; non-plastic; saturated; gray, (5Y 5/1).
25.0	1394.0			12:26:30:28	25.0	1.6	NR	SP(50%)	COARSE SAND; well sorted; subround to round; spherical, trace discoidal; loose; non-plastic; saturated; light gray to gray, (5Y 5.5/1).
								SW(50%)	VERY COARSE SAND, some fine to medium pebbles, trace clay pockets; very poorly sorted; subround to round; spherical, trace discoidal; loose; non-plastic; saturated; light gray to gray, (5Y 5.5/1).

NR Not Recorded

MONITORING WELL CONSTRUCTION SUMMARY

Well No. : MW-1-10
Location (SD Coord.)
Northings : 471,974.5
Eastings : 2,953,329.9
Reference Point : TOP OF PVC CASING
Reference Point Elev. : 1418.72 MSL
Type of Security : VAULT

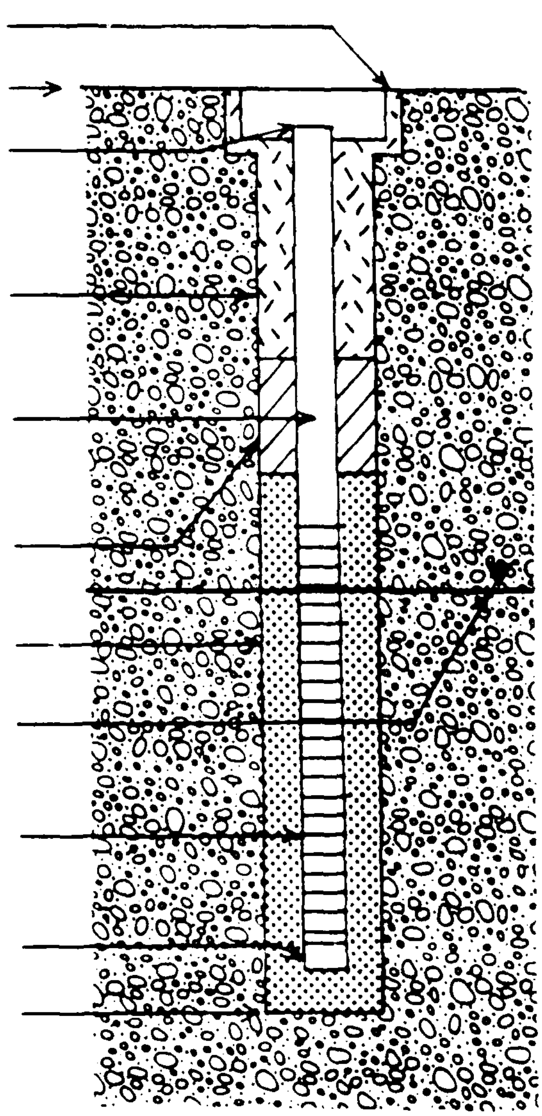
Development
Date : 4/26/89
Type : PUMPING
Volume Purged : 1081 GALLONS

Water Level/Date: 1407.15 MSL-5/3/89

Supervisory Geologist : D. VanWINKLE
Log Book/Page No. : 2/43-46
Drilling Company : LAYNE (OMAHA)
Rig Type : HOLLOW-STEM AUGER
Driller : L. HRABIK
Drilling Started : 4/26/89 0700
Drilling Completed : 4/26/89 1400

MONITORING WELL AS-BUILT

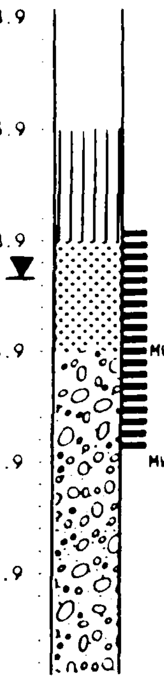
		BLS	MSL
Watertight Vault			
Land Surface		0.0	1419.0
Top of PVC Flush Joint Riser w/Locking PVC Cap		0.3	1418.72
Cement/Bentonite Grout	Top	1.0	1418.0
	Bottom	3.9	1415.1
4" I.D. Schedule 40 PVC Flush Joint Riser	Top	0.3	1418.7
	Bottom	8.9	1410.1
Bentonite 1/4" Pellet Seal	Top	3.9	1415.1
	Bottom	5.5	1413.5
Sand Pack	Top	5.5	1413.5
	Bottom	28.0	1391.0
Static Water Level	5/03/89	11.82	1407.15
4" I.D. Schedule 40 PVC Flush Joint Screen 0.040" Slot 4 Slots/Inch	Top	8.9	1410.1
	Bottom	18.9	1400.1
Bottom Plug		19.4	1399.6
12" Borehole Total Depth		28.0	1391.0



NOT TO SCALE

All measurements in feet unless otherwise noted
BLS - Below Land Surface
MSL - Mean Sea Level Datum

MONITORING WELL BORING NO.	MW1 11	JOE FOSS FIELD	DRILLING COMPANY	LAYNE WESTERN
SUPERVISORY GEOLOGIST	D. VANWINKLE	MONITORING WELL LOG	RIG TYPE	HOLLOW STEM AUGER (CME 75)
LOG BOOK/PG No.	2/45,47-48			
DRILLING STARTED	4-26-89			
COMPLETION DATE	4-26-89			



DEPTH (BLS)	ELEV (MSL)	LITHOLOGIC SYMBOLS	LAB SAMPLE NUMBER	BLOW COUNT	TOP OF SAMPLE ('BLS)	RECOVERY (feet)	HNU (PPM)	SOIL TYPE (USCS)	LITHOLOGIC DESCRIPTION
0.0	1418.9								
5.0	1413.9			5:8:15:15	5.0	1.2	NR	CL	SANDY CLAY; poorly sorted; subangular to round; spherical; soft; slightly plastic; moist; olive gray, (5Y 4/2), iron oxide stains.
10.0	1408.9			6:11:12:14	10.0	1.5	0.2	SP	MEDIUM SAND, trace coarse sand; well sorted; subround to round; spherical; loose; non-plastic; moist to wet (11.7 feet BLS); grayish brown, (2.5Y 5/2).
15.0	1403.9		MW1-11-15	8:15:16:16	15.0	1.4	0.2	GW	FINE TO MEDIUM PEBBLEY GRAVEL, some very coarse sand; very poorly sorted; subround to round; spherical, some discoidal; loose; non-plastic; saturated; grayish brown to dark grayish brown, (2.5Y 4.5/2).
20.0	1398.9		MW1-11-20	7:7:7:12	20.0	1.1	0.2	GW	FINE TO MEDIUM PEBBLEY GRAVEL, some very coarse sand, trace fine cobbles; very poorly sorted; subround to round; spherical, some discoidal, trace prismoidal; loose; non-plastic; saturated; gray to dark gray, (5Y 4.5/1).
25.0	1393.9			6:8:13:17	25.0	1.1	0.2	GW	FINE TO MEDIUM PEBBLEY GRAVEL, some very coarse sand, trace fine cobbles; very poorly sorted; subround to round; spherical, some discoidal, trace prismoidal; loose; non-plastic; saturated; gray to dark gray, (5Y 4.5/1).

NR- Not Recorded

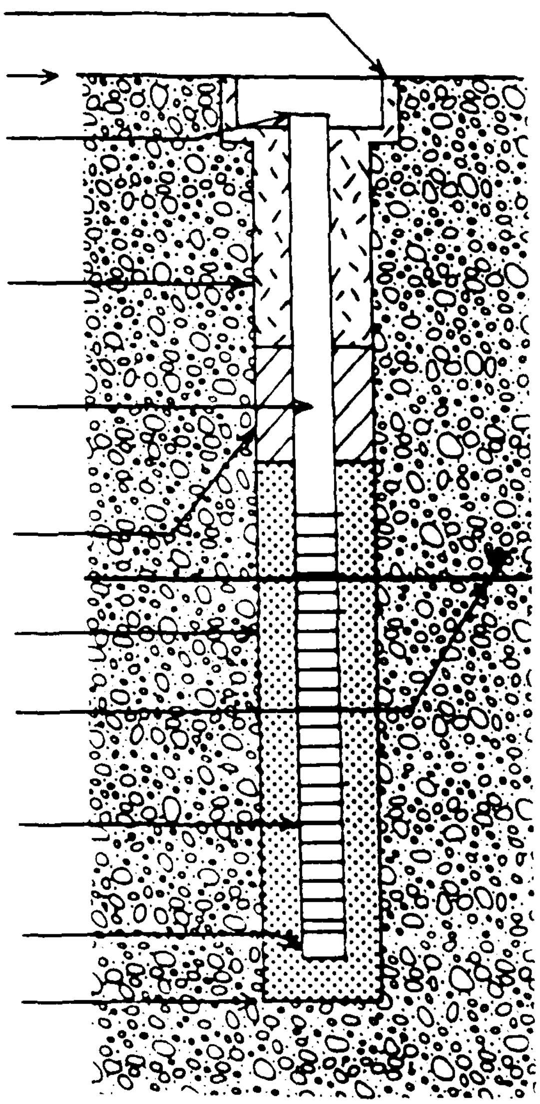
MONITORING WELL CONSTRUCTION SUMMARY

Well No.	: MW-1-11	Development		
Location (SD Coord.)		Date	:	4/26/89
Northings	: 472,226.8	Type	:	PUMPING
Eastings	: 2,953,223.6	Volume Purged	:	1196 GALLONS
Reference Point	: TOP OF PVC CASING			
Reference Point Elev.	: 1418.73 MSL	Water Level/Date:		1407.08 MSL-5/3/89
Type of Security	: VAULT			

Supervisory Geologist	: D. VanWINKLE
Log Book/Page No.	: 2/45-48
Drilling Company	: LAYNE (OMAHA)
Rig Type	: HOLLOW-STEM AUGER
Driller	: L. HRABIK
Drilling Started	: 4/26/89 1400
Drilling Completed	: 4/26/89 2015

MONITORING WELL AS-BUILT

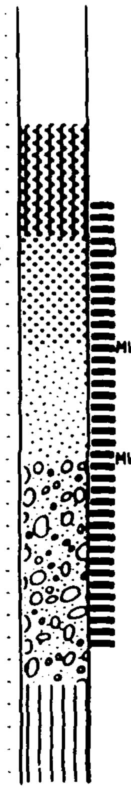
		BLS	MSL
Watertight Vault			
Land Surface		0.0	1418.9
Top of PVC Flush Joint Riser w/Locking PVC Cap		0.2	1418.73
Cement/Bentonite Grout	Top	1.0	1417.9
	Bottom	5.2	1413.7
4" I.D. Schedule 40 PVC Flush Joint Riser	Top	0.2	1418.7
	Bottom	9.7	1409.2
Bentonite 1/4" Pellet Seal	Top	5.2	1413.7
	Bottom	6.8	1412.1
Sand Pack	Top	6.8	1412.1
	Bottom	25.0	1393.9
Static Water Level	5/03/89	11.85	1407.08
4" I.D. Schedule 40 PVC Flush Joint Screen 0.040" Slot 4 Slots/Inch	Top	9.7	1409.2
	Bottom	19.7	1399.2
Bottom Plug		20.2	1398.7
12" Borehole Total Depth		25.0	1393.9



NOT TO SCALE

All measurements in feet unless otherwise noted
BLS - Below Land Surface
MSL - Mean Sea Level Datum

MONITORING WELL BORING NO.	MW1-12	JOE FOSS FIELD	DRILLING COMPANY	LAYNE-WESTERN
SUPERVISORY GEOLOGIST	D. VANWINKLE	MONITORING WELL LOG	RIG TYPE	HOLLOW-STEM AUGER
LOG BOOK/PG No.	2/52-54,57			
DRILLING STARTED	4-27-89			
COMPLETION DATE	4-28-89			



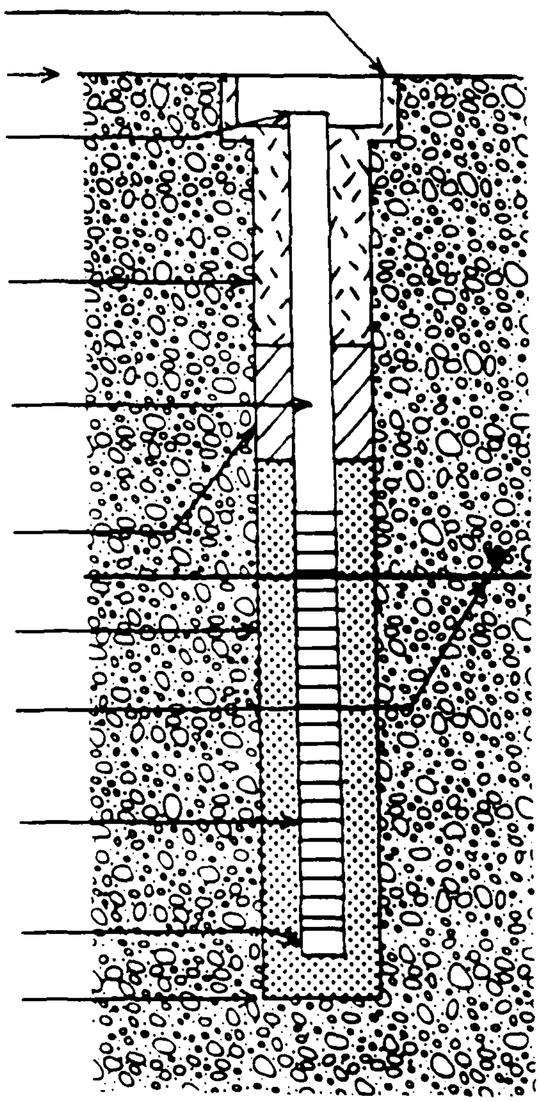
DEPTH (BLS)	ELEV (MSL)	LITHOLOGIC SYMBOLS	LAB SAMPLE NUMBER	BLOW COUNT	TOP OF SAMPLE ('BLS)	RECOVERY (feet)	HNU (PPM)	SOIL TYPE (USCS)	LITHOLOGIC DESCRIPTION
0.0	1418.7								
5.0	1413.7			5:4:3:3	5.0	1.2	0.2	SC	MEDIUM TO COARSE CLAYEY SAND; poorly sorted; subround to round; spherical, trace discoidal; soft; slightly plastic; moist; dark grayish brown; (2.5Y 4/2), iron oxide stains.
10.0	1408.7			7:12:14:15	10.0	1.5	0.2	SP	COARSE SAND, trace fine pebbles; moderately sorted; subround to round; spherical, trace discoidal; loose; non-plastic; moist to wet (11.1 feet BLS); brown, (10YR 5/3).
15.0	1403.7		MW1-12-15	18:22:28:26	15.0	1.9	3.0	SW	VERY COARSE SAND, trace fine to medium pebbles; poorly sorted; subround to round; spherical, trace discoidal; loose; non-plastic; saturated; dark gray, (5Y 4.5/2); hydrocarbon odor.
20.0	1398.7		MW1-12-20	8:22:30:26	20.0	1.3	0.2	GW	*FINE TO MEDIUM PEBBLY GRAVEL*, some very coarse sand; very poorly sorted; subangular to round; spherical, some discoidal, trace prismoidal; loose; non-plastic; saturated; gray to dark gray, (5Y 4.5/1); hydrocarbon odor.
25.0	1393.7			9:19:36:26	25.0	1.3	0.2	GW	FINE TO MEDIUM PEBBLY GRAVEL, some very coarse sand; very poorly sorted; subround to round; spherical, some discoidal, trace prismoidal; loose; non-plastic; saturated; gray to dark gray, (5Y 4.5/1); hydrocarbon odor.
30.0	1388.7			3:2:1:2	30.0	0.8	0.2	CL	CLAY, trace coarse sand to medium pebbles; poorly sorted; firm; slightly plastic; moist; light gray to gray, (5Y 5.5/1); glacial till.

MONITORING WELL CONSTRUCTION SUMMARY

Well No.	:	MW-1-12	Development	
Location (SD Coord.)			Date	: 4/28/89
Northings	:	472,152.0	Type	: PUMPING
Eastings	:	2,953,134.7	Volume Purged	: 1173 GALLONS
Reference Point	:	TOP OF PVC CASING		
Reference Point Elev.	:	1418.20 MSL	Water Level/Date:	1407.05 MSL-5/3/89
Type of Security	:	VAULT		
Supervisory Geologist	:	D. VanWINKLE		
Log Book/Page No.	:	2/52-54		
Drilling Company	:	LAYNE (OMAHA)		
Rig Type	:	HOLLOW-STEM AUGER		
Driller	:	L. HRABIK		
Drilling Started	:	4/27/89 1400		
Drilling Completed	:	4/27/89 1930		

MONITORING WELL AS-BUILT

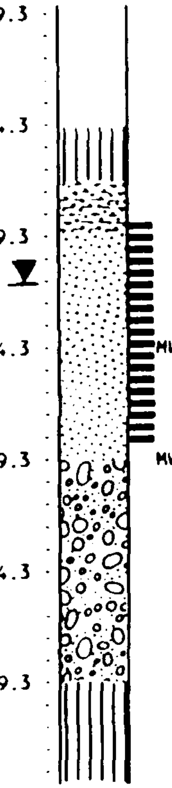
		BLS	MSL
Watertight Vault			
Land Surface		0.0	1418.6
Top of PVC Flush Joint Riser w/Locking PVC Cap		0.4	1418.20
Cement/Bentonite Grout	Top	1.0	1417.6
	Bottom	3.2	1415.4
4" I.D. Schedule 40 PVC Flush Joint Riser	Top	0.4	1418.2
	Bottom	8.1	1410.5
Bentonite 1/4" Pellet Seal	Top	3.2	1415.4
	Bottom	4.5	1414.1
Sand Pack	Top	4.5	1414.1
	Bottom	30.0	1388.6
Static Water Level	5/03/89	11.55	1407.05
4" I.D. Schedule 40 PVC Flush Joint Screen 0.040" Slot 4 Slots/Inch	Top	8.1	1410.5
	Bottom	28.1	1390.5
Bottom Plug		28.6	1390.0
12" Borehole Total Depth		30.0	1388.6



NOT TO SCALE

All measurements in feet unless otherwise noted
BLS - Below Land Surface
MSL - Mean Sea Level Datum

MONITORING WELL BORING NO.	MW1-13	JOE FOSS FIELD	DRILLING COMPANY	LAYNE-WESTERN
SUPERVISORY GEOLOGIST	D. VANWINKLE	MONITORING WELL LOG	RIG TYPE	HOLLOW-STEM AUGER
LOG BOOK/PG No.	2/49-51			
DRILLING STARTED	4-27-89			
COMPLETION DATE	4-27-89			



DEPTH (BLS)	ELEV (MSL)	LITHOLOGIC SYMBOLS	LAB SAMPLE NUMBER	BLOW COUNT	TOP OF SAMPLE ('BLS)	RECOVERY (feet)	HNU (PPM)	SOIL TYPE (USCS)	LITHOLOGIC DESCRIPTION
0.0	1419.3								
5.0	1414.3			8:16:19:16	5.0	1.5	0.2	CL(50%) SM(50%)	CLAY, trace sand; soft; plastic; moist; very dark gray, (10YR [illegible]/1). MEDIUM TO VERY COARSE SAND, some silt, clay; poorly sorted; subround to round; spherical, trace discoidal; loose; non-plastic; moist; grayish brown to dark grayish brown, (2.5Y 4.5/2).
10.0	1409.3			7:11:19:19	10.0	1.4	0.2	SW	COARSE SAND, some fine pebbles; poorly sorted; subround to round; spherical, trace discoidal, prismoidal; loose; non-plastic; moist; dark grayish brown, (10YR 5/3).
15.0	1404.3		MW1-13-15	4:11:15:15	15.0	1.5	0.2	SW	MEDIUM TO VERY COARSE SAND, some fine to medium pebbles, trace bituminous coal; very poorly sorted; subround to round; spherical, trace discoidal, prismoidal; loose; non-plastic; saturated (encountered water approx. 12.5 feet BLS); dark grayish brown, (2.5Y 4/2).
20.0	1399.3		MW1-13-20	16:17:21:18	20.0	1.3	0.2	GW	FINE TO MEDIUM PEBBLY GRAVEL, trace cobbles, very coarse sand; very poorly sorted; subround to round; spherical, some discoidal; loose; non-plastic; saturated; gray, (5Y 5/1).
25.0	1394.3			17:23:18:18	25.0	1.0	0.2	GW	FINE TO MEDIUM PEBBLY GRAVEL, some very coarse sand, trace cobbles; very poorly sorted; subround to round; spherical, some discoidal; loose; non-plastic; saturated; gray, (5Y 5/1).
30.0	1389.3			3:2:1:2	30.0	0.8	0.2	CL	CLAY, trace coarse sand to medium pebbles; poorly sorted; firm; slightly plastic; moist; light gray to gray, (5Y 5.5/1); glacial till.

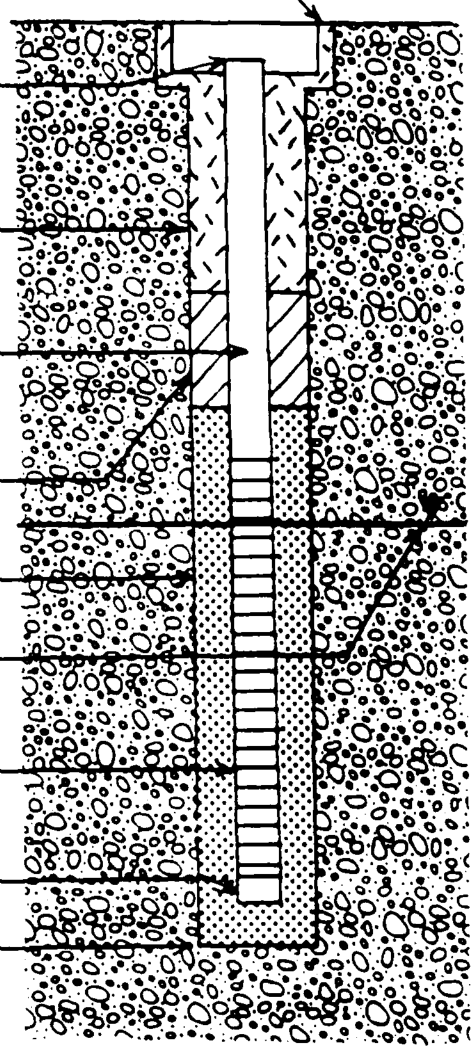
MONITORING WELL CONSTRUCTION SUMMARY

Well No.	:	MW-1-13
Location (SD Coord.)		
Northings	:	471,622.6
Eastings	:	2,953,295.6
Reference Point	:	TOP OF PVC CASING
Reference Point Elev.	:	1419.34 MSL
Type of Security	:	VAULT
Supervisory Geologist	:	D. VanWINKLE
Log Book/Page No.	:	2/49-51
Drilling Company	:	LAYNE (OMAHA)
Rig Type	:	HOLLOW-STEM AUGER
Driller	:	L. HRABIK
Drilling Started	:	4/27/89 0700
Drilling Completed	:	4/27/89 1400

Development		
Date	:	4/27/89
Type	:	PUMPING
Volume Purged	:	1380 GALLONS
Water Level/Date:		1407.24 MSL-5/3/89

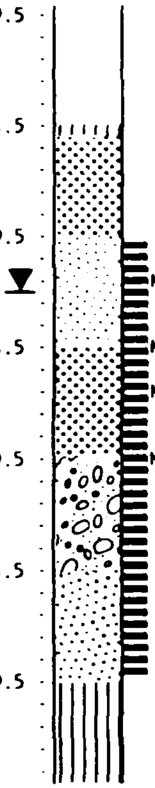
MONITORING WELL AS-BUILT

		BLS	MSL
Watertight Vault			
Land Surface		0.0	1419.3
Top of PVC Flush Joint Riser w/Locking PVC Cap		0.0	1419.34
Cement/Bentonite Grout	Top	1.0	1418.3
	Bottom	4.1	1415.2
4" I.D. Schedule 40 PVC Flush Joint Riser	Top	0.0	1419.3
	Bottom	9.3	1410.0
Bentonite 1/4" Pellet Seal	Top	4.1	1415.2
	Bottom	5.9	1413.4
Sand Pack	Top	5.9	1413.4
	Bottom	25.0	1394.3
Static Water Level	5/03/89	12.10	1407.24
4" I.D. Schedule 40 PVC Flush Joint Screen 0.040" Slot 4 Slots/Inch	Top	9.3	1410.0
	Bottom	19.3	1400.0
Bottom Plug		19.8	1399.5
12" Borehole Total Depth		25.0	1394.3


NOT TO SCALE

All measurements in feet unless otherwise noted
BLS - Below Land Surface
MSL - Mean Sea Level Datum

MONITORING WELL BORING NO.	MW1-14	JOE FOSS FIELD		DRILLING COMPANY	LAYNE-WESTERN
SUPERVISORY GEOLOGIST	D. VANWINKLE	MONITORING WELL LOG		RIG TYPE	HOLLOW-STEM AUGER
LOG BOOK/PG No.	2/56,59-60				
DRILLING STARTED	4-28-89				
COMPLETION DATE	4-29-89				



DEPTH (BLS)	ELEV (MSL)	LITHOLOGIC SYMBOLS	LAB SAMPLE NUMBER	BLOW COUNT	TOP OF SAMPLE ('BLS)	RECOVERY (feet)	HNU (PPM)	SOIL TYPE (USCS)	LITHOLOGIC DESCRIPTION
0.0	1419.5								
5.0	1414.5			8:14:17:17	5.0	1.5	NR	CL(5%)	SILTY CLAY, some medium sand, trace fine to medium pebbles, cobbles; poorly sorted; round; spherical; slightly plastic; moist; dark grayish brown, (10YR 3/2).
								SP(95%)	MEDIUM TO COARSE SAND, trace fine pebbles; moderately sorted; subround to round; spherical; loose; non-plastic; moist; light yellowish brown, (10YR 6/4).
10.0	1409.5			9:12:16:23	10.0	1.9	NR	SW	MEDIUM TO VERY COARSE SAND, some fine to medium pebbles; very poorly sorted; subangular to round; spherical, some discoidal, trace prismoidal; loose; non-plastic; moist to wet (approx. 11.6 feet BLS); light yellowish brown to dark brown, (10YR 6/4 to 10YR 3.5/3).
			MW1-14-12*						
15.0	1404.5		MW1-14-15	6:11:20:24	15.0	2.0	NR	SP	MEDIUM TO VERY COARSE SAND; moderately sorted; subround to round; spherical, trace discoidal, prismoidal; loose; non-plastic; saturated; brown, (10YR5/3).
			MW1-14-17*						
20.0	1399.5		MW1-14-20	10:14:16:24	20.0	1.3	NR	GW	FINE TO MEDIUM PEBBLY GRAVEL; very poorly sorted; subround to round; spherical, some discoidal, trace prismoidal; loose; non-plastic; saturated; grayish brown, (2.5Y 5/2); slight hydrocarbon odor.
25.0	1394.5			6:12:40:30	25.0	1.4	0.2	SW	COARSE TO VERY COARSE SAND, trace fine pebbles; poorly sorted; subround to round; spherical, some discoidal, trace prismoidal; loose; non-plastic; saturated; gray to dark gray, (5Y 4.5/1).
30.0	1389.5			3:2:1:2	30.0	0.8	0.2	CL	CLAY, trace coarse sand to medium pebbles; poorly sorted; firm; slightly plastic; moist; light gray to gray, (5Y 5.5/1); glacial till.

NR-Not Recorded
*-Geotechnical Sample

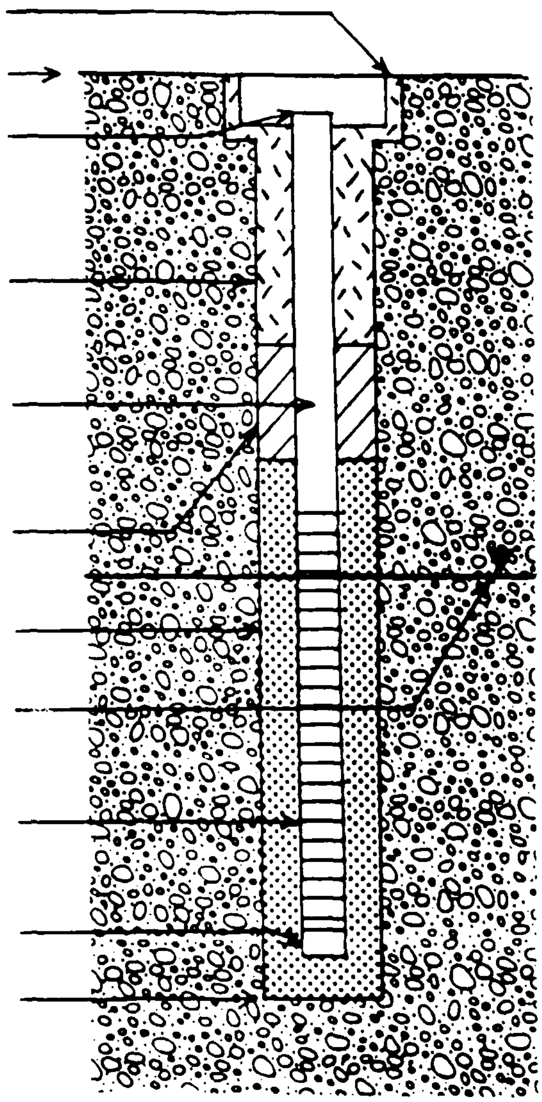
MONITORING WELL CONSTRUCTION SUMMARY

Well No.	: MW-1-14	Development	
Location (SD Coord.)		Date	: 4/29/89
Northings	: 472,343.8	Type	: PUMPING
Eastings	: 2,953,016.8	Volume Purged	: 1840 GALLONS
Reference Point	: TOP OF PVC CASING		
Reference Point Elev.	: 1418.87 MSL	Water Level/Date:	1406.97 MSL-5/3/89
Type of Security	: VAULT		

Supervisory Geologist	: D. VanWINKLE
Log Book/Page No.	: 2/56-59
Drilling Company	: LAYNE (OMAHA)
Rig Type	: HOLLOW-STEM AUGER
Driller	: L. HRABIK
Drilling Started	: 4/28/89 0700
Drilling Completed	: 4/28/89 1430

MONITORING WELL AS-BUILT

		BLS	MSL
Watertight Vault			
Land Surface		0.0	1419.5
Top of PVC Flush Joint Riser w/Locking PVC Cap		0.7	1418.87
Cement/Bentonite Grout	Top	1.0	1418.5
	Bottom	5.3	1414.2
4" I.D. Schedule 40 PVC Flush Joint Riser	Top	0.7	1418.9
	Bottom	10.2	1409.3
Bentonite 1/4" Pellet Seal	Top	5.3	1414.2
	Bottom	6.8	1412.7
Sand Pack	Top	6.8	1412.7
	Bottom	25.0	1394.5
Static Water Level	5/03/89	12.55	1406.97
4" I.D. Schedule 40 PVC Flush Joint Screen 0.040" Slot 4 Slots/Inch	Top	10.2	1409.3
	Bottom	20.2	1399.3
Bottom Plug		20.7	1398.8
12" Borehole Total Depth		25.0	1394.5

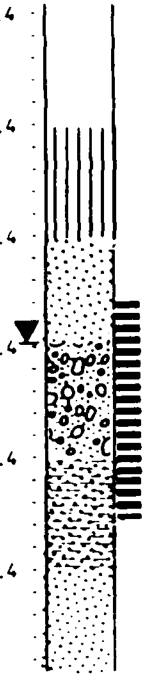


All measurements in feet unless otherwise noted
BLS - Below Land Surface
MSL - Mean Sea Level Datum

NOT TO SCALE

SITE 3-BASE FIRE TRAINING AREA

MONITORING WELL BORING NO.	MW3-5	JOE FOSS FIELD	DRILLING COMPANY: LAYNE-WESTERN
SUPERVISORY GEOLOGIST	J.CARTER	MONITORING WELL LOG	RIG TYPE: HOLLOW-STEM AUGER
LOG BOOK/PG No.	2/15-17		
DRILLING STARTED	4-15-89		
COMPLETION DATE	4-25-89		



DEPTH (BLS)	ELEV (MSL)	LITHOLOGIC SYMBOLS	LAB SAMPLE NUMBER	BLOW COUNT	TOP OF SAMPLE ('BLS)	RECOVERY	HNU	SOIL TYPE (USCS)	LITHOLOGIC DESCRIPTION
0.0	1422.4								
5.0	1417.4			4:6:8:8	5.0	0.6	0.0	CL	CLAY, trace sand, gravel; firm; slightly plastic; moist; dark greenish gray, (5GY 4/1), stained.
10.0	1412.4			8:13:18:18	10.0	1.3	0.0	SW	MEDIUM TO COARSE SAND, some gravel; poorly sorted; subangular to subround; subprismoidal; loose; non-plastic; dry; brown, (10YR 5/3).
15.0	1407.4			7:17:17:14	15.0	1.3	0.0	GW	GRAVEL, some medium to coarse sand; poorly sorted; subangular to subround; subprismoidal; loose; non-plastic; wet; brown, (10YR 5/3).
20.0	1402.4			4:12:14:14	20.0	1.1	0.0	SM	COARSE SAND, some silt, trace gravel; poorly sorted; subangular to subround; subprismoidal to spherical; loose; non-plastic; wet; brown, (10YR 5/3).
25.0	1397.4			7:14:29:24	25.0	1.0	0.0	SW	MEDIUM TO COARSE SILTY SAND, some gravel; poorly sorted; subangular to subround; subprismoidal to spherical; loose; non-plastic; wet; brown, (10YR 5/3).

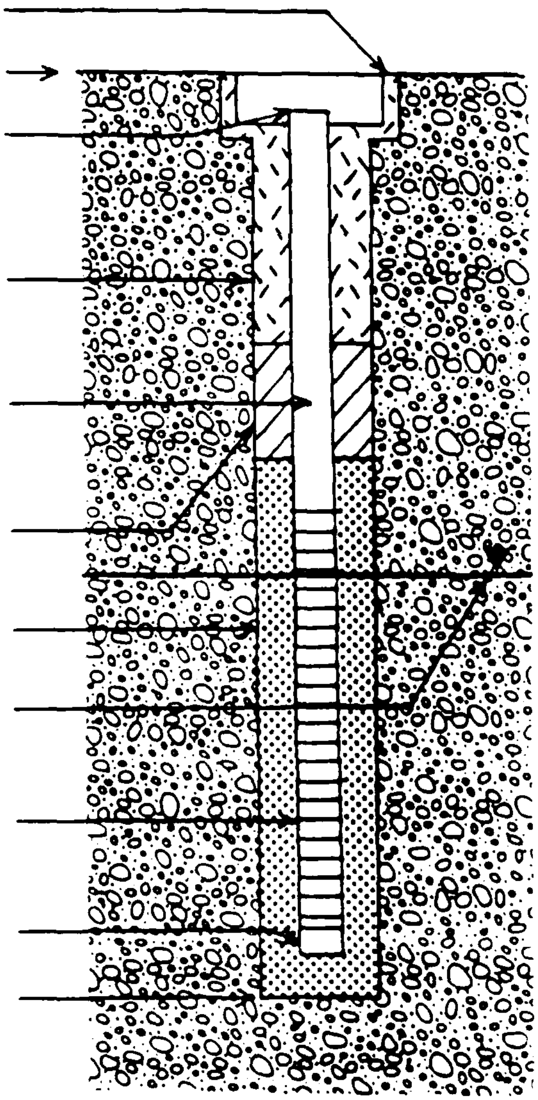
MONITORING WELL CONSTRUCTION SUMMARY

Well No.	:	MW-3-5	Development		
Location (SD Coord.)			Date	:	5/1/89
Northings	:	476,197.9	Type	:	PUMPING
Eastings	:	2,948,819.5	Volume Purged	:	1196 GALLONS
Reference Point	:	TOP OF PVC CASING			
Reference Point Elev.	:	1422.60 MSL	Water Leval/Date:		1407.48 MSL-5/3/89
Type of Security	:	VAULT			

Supervisory Geologist	:	D. VanWINKLE
Log Book/Page No.	:	2/15-17
Drilling Company	:	LAYNE (OMAHA)
Rig Type	:	HOLLOW-STEM AUGER
Driller	:	L. HRABIK
Drilling Started	:	4/15/89 1015
Drilling Completed	:	4/15/89 1015

MONITORING WELL AS-BUILT

		BLS	MSL
Watertight Vault			
Land Surface		0.0	1422.5
Top of PVC Flush Joint Riser w/Locking PVC Cap		-0.1	1422.60
Cement/Bentonite Grout	Top	1.0	1421.5
	Bottom	8.0	1414.5
4" I.D. Schedule 40 PVC Flush Joint Riser	Top	-0.1	1422.6
	Bottom	13.0	1409.5
Bentonite 1/4" Pellet Seal	Top	8.0	1414.5
	Bottom	10.0	1412.5
Sand Pack	Top	10.0	1412.5
	Bottom	25.0	1397.5
Static Water Level	5/03/89	15.02	1407.48
4" I.D. Schedule 40 PVC Flush Joint Screen 0.040" Slot 4 Slots/Inch	Top	13.0	1409.5
	Bottom	23.0	1399.5
Bottom Plug		23.5	1399.0
12" Borehole Total Depth		25.0	1397.5



NOT TO SCALE

All measurements in feet unless otherwise noted
BLS - Below Land Surface
MSL - Mean Sea Level Datum

SOIL BORING NO.	B3-1	JOE FOSS FIELD	DRILLING COMPANY: LAYNE-WESTERN
SUPERVISORY GEOLOGIST	J. CARTER	SOIL BORING LOG	RIG TYPE: HOLLOW-STEM AUGER
LOG BOOK/PG No.	2/4-7		
DRILLING STARTED	4-14-89		
ABANDONMENT COMPLETED	4-16-89		

DEPTH (BLS)	LITHOLOGIC SYMBOLS	LAB SAMPLE NUMBER	BLOW COUNT	TOP OF SAMPLE ('BLS)	RECOVERY	HNU	SOIL TYPE (USCS)	LITHOLOGIC DESCRIPTION
0.0		B3-1-0	2:5:10:8	0.0	0.9	0.2	CL	CLAY, trace silt; well sorted; soft; non-plastic; moist; black, (2.5Y 2/0); hydrocarbon odor.
2.5		B3-1-2*	NA	--	NA	NR		SHELBY TUBE (2.0 - 4.0)
5.0		B3-1-5	3:8:12:17	5.0	1.8	22	CL	CLAY, trace silt; well sorted; soft to firm; slightly plastic; moist; black, (5YR 2.5/1), sheen; strong hydrocarbon odor.
7.5			5:12:15:24	7.5	1.3	7	CL	CLAY, trace scattered sand, trace nodules of angular material; well sorted; subangular to subround; spherical; stiff; slightly plastic to plastic; semi-moist; black, (2.5YR2.5/0); faint hydrocarbon odor.
10.0			5:17:21:26	10.0	1.1	1	SM	MEDIUM TO COARSE SAND, trace gravel, trace silt; poorly sorted; angular to subround; prismoidal and discoidal; loose; non-plastic; semi-moist gray, (5Y 6/1).
12.5		B3-1-12*	NA	--	NA	NR		SHELBY TUBE (12.0 - 14.0)
15.0			9:17:19:19	15.0	1.4	0.1	SM	MEDIUM TO COARSE SAND, some gravel, trace silt; poorly sorted; angular to subround; prismoidal and discoidal; loose; non-plastic; moist; light olive gray, (5Y 6/2).

NR-Not Recorded
NA-Not Applicable
*-Geotechnical Sample

SOIL BORING NO.	B3 2	JOE FOSS FIELD		DRILLING COMPANY	LAYNE-WESTERN
SUPERVISORY GEOLOGIST	J. CARTER	SOIL BORING LOG		RIG TYPE	HOLLOW-STEM AUGER
LOG BOOK/PG No.	2/12-13				
DRILLING STARTED	4-14-89				
ABANDONMENT COMPLETED	4-16-89				

DEPTH (BLS)	LITHOLOGIC SYMBOLS	LAB SAMPLE NUMBER	BLOW COUNT	TOP OF SAMPLE ('BLS)	RECOVERY	HNU	SOIL TYPE (USCS)	LITHOLOGIC DESCRIPTION
0.0		B3 2-0	6:5:8:9	0.0	1.3	0.0	CL(50%)	SILTY CLAY; soft to firm; non-plastic; semi-moist; very dusky red, (5R 2.5/3).
							SM(50%)	MEDIUM TO COARSE SAND, some pebbles; poorly sorted; subangular to subround; loose; non-plastic; semi-moist; dark brown, (7.5YR 4/6).
2.5			3:5:6:8	2.5	1.4	0.1	CL	SILTY CLAY; moderately to well sorted; soft; non-plastic; semi- to very moist; black, (5Y 2.5/1).
5.0		B3 2-5	7:9:3:8	5.0	1.5	0.1	CL	SILTY CLAY, sand stringers; moderately to well sorted; soft; non-plastic; moist; very dark grayish brown, (2.5Y 3/2).
7.5			3:5:7:7	7.5	1.5	0.0	SM(25%)	MEDIUM TO COARSE SAND, (stringers), some clay; poorly to moderately sorted; spherical and discoidal; loose; non-plastic; semi-moist; dark yellowish brown, (10YR 4/4).
							CL(75%)	SILTY CLAY; soft; non-plastic; moist; black, (5Y 2.5/1).
10.0			5:6:6:8	10.0	1.7	0.0	SM(25%)	MEDIUM TO COARSE SAND, some gravel (stringers through clay); poorly sorted; subangular to subround; loose; non-plastic; moist; dark yellowish brown, (10YR 4/4).
							CL(75%)	CLAY, some silt; soft; very plastic; moist; black, (5Y 2.5/1), stained; banded.

SOIL BORING NO.	B3-3	JOE FOSS FIELD	DRILLING COMPANY: LAYNE-WESTERN
SUPERVISORY GEOLOGIST	J. CARTER	SOIL BORING LOG	RIG TYPE: HOLLOW-STEM AUGER
LOG BOOK/PG No.	2/12-13		
DRILLING STARTED	4-14-89		
ABANDONMENT COMPLETED	4-16-89		

DEPTH (BLS)	LITHOLOGIC SYMBOLS	LAB SAMPLE NUMBER	BLOW COUNT	TOP OF SAMPLE ('BLS)	RECOVERY	HNU	SOIL TYPE (USCS)	LITHOLOGIC DESCRIPTION
0.0		B3-3-0	3:4:5:10	0.0	1.6	110.0	CL(50%)	CLAY, trace gravel; soft to firm; slightly plastic; moist; black, (5Y 2.5/1); strong hydrocarbon odor.
							SW(50%)	MEDIUM TO COARSE SAND, some gravel; poorly sorted; subangular to subround; subprismoidal; loose; non-plastic; moist; dark yellowish brown, (10YR 4/4); strong hydrocarbon odor.
2.5		B3-3-2.5	3:5:8:12	2.5	1.4	50.0	CL(90%)	CLAY, trace sand; soft; slightly plastic; moist; black, (5Y 2.5/1); hydrocarbon odor.
							SW(10%)	MEDIUM TO COARSE SAND, some gravel; poorly sorted; subangular to subround; subprismoidal; loose; non-plastic; moist; dark yellowish brown, (10YR 4/4); hydrocarbon odor.
5.0			5:12:15:20	5.0	2.0	30.0	CL	CLAY, trace sand, trace light gray nodules (undetermined composition); firm; slightly plastic; moist; black, (5Y 2.5/1), sheen; slight hydrocarbon odor.
7.5			8:11:15:17	7.5	2.0	110.0	CL	CLAY, trace sand, gravel, trace light gray nodules (undetermined composition); poorly sorted; firm to stiff; slightly plastic; moist; very dark gray, (5YR 3/1), sheen; hydrocarbon odor.
10.0			4:5:6:15	10.0	1.1	200.0	CL	CLAY, trace sand, gravel, trace light gray nodules (undetermined composition); poorly sorted; subangular; firm to stiff; slightly plastic; moist; very dark gray, (5YR 3/1) sheen; hydrocarbon odor.
12.5			12:17:34:39	12.5	2.0	0.6	SW	MEDIUM SAND, some gravel, trace silt; very poorly sorted; subangular to subround; subprismoidal to subdiscoidal; loose; non-plastic; moist; light gray to gray, (5Y 6/1)
15.0			5:12:27:30	15.0	1.7	2.6	SW	MEDIUM SAND, some gravel; poorly sorted; subangular to subround; subprismoidal to subdiscoidal; loose; non-plastic; moist; light gray to gray, (5Y 6/1).
17.5			9:24:18:22	17.5	1.6	0.0	GM	GRAVEL, some sand; poorly sorted; subround to round; subprismoidal to spherical; loose; non-plastic; wet; light olive brown, (2.5Y 5/6).

SOIL BORING NO.	B3-4	JOE FOSS FIELD	DRILLING COMPANY	LAYNE-WESTERN
SUPERVISORY GEOLOGIST	J. CARTER	SOIL BORING LOG	RIG TYPE	HOLLOW-STEM AUGER
LOG BOOK/PG No.	2/15			
DRILLING STARTED	4-15-89			
ABANDONMENT COMPLETED	4-16-89			

DEPTH (BLS)	LITHOLOGIC SYMBOLS	LAB SAMPLE NUMBER	BLOW COUNT	TOP OF SAMPLE ('BLS)	RECOVERY	HNU	SOIL TYPE (USCS)	LITHOLOGIC DESCRIPTION
0.0		B3-4-0	3:10:12:16	0.0	1.0	0.0	CL	CLAY, some silt, trace gravel, sand; soft to firm; slightly plastic; moist; black, (5Y 2.5/1).
2.5		B3-4-2*	NA	--	NA	NR		SHELBY TUBE (2.0 - 4.0)
5.0		B3-4-5	3:11:10:19	5.0	1.3	0.0	CL	CLAY, trace sand, nodules (undetermined composition); soft to firm; plastic; moist; black, (5Y 2.5/), sheen, some discoloration, mottled appearance.
7.5			3:8:10:13	7.5	1.6	0.0	CL	CLAY, trace sand; firm, plastic, moist; black, (5Y 2.5/2), some discoloration, and staining.
10.0			3:4:13:14	10.0	1.8	0.0	SW(10%)	MEDIUM TO COARSE SAND, some gravel; poorly sorted; subangular to subround; subprismoidal; loose; non-plastic; moist; light gray to gray, (5Y 6/1).
							CL(90%)	SILTY CLAY, trace sand; firm; slightly plastic; moist; black, (5Y 2.5/2).
12.0		B3-4-12*	NA	--	NA	NR		SHELBY TUBE (12.0 - 14.0)

NR-Not Recorded
NA-Not Applicable
*-Geot chnical Sample

SOIL BORING NO.	B3-5	JOE FOSS FIELD	DRILLING COMPANY	LAYNE-WESTERN
SUPERVISORY GEOLOGIST	J. CARTER	SOIL BORING LOG	RIG TYPE	HOLLOW-STEM AUGER
LOG BOOK/PG No.	2/15			
DRILLING STARTED	4-15-89			
ABANDONMENT COMPLETED	4-16-89			

DEPTH (BLS)	LITHOLOGIC SYMBOLS	LAB SAMPLE NUMBER	BLOW COUNT	TOP OF SAMPLE ('BLS)	RECOVERY	HNU	SOIL TYPE (USCS)	LITHOLOGIC DESCRIPTION
0.0		B3-5-0	5:10:15:13	0.0	1.1	0.0	CL	CLAY, trace gravel (nodules of undetermined composition), trace silt and medium to coarse sand; poorly sorted; subround; subprismoidal; soft to firm; non-plastic; moist; very dark gray, (10YR 3/1).
2.5		B3-5-2* B3-5-2.5	5:10:12:12	2.5	1.5	0.0	CL	SILTY CLAY, trace sand, nodules (undetermined composition); soft; non-plastic; moist; very dark gray, (10YR 3/1), discoloration.
5.0			5:8:8:10	5.0	1.5	0.0	CL	SILTY CLAY, trace sand (banded), nodules (undetermined composition); soft; non-plastic; moist; dark gray, (10YR 4/1), discoloration.
7.5			6:6:6:6	7.5	1.6	0.0	CL(60%)	SILTY CLAY; soft; non-plastic; dark gray, (10YR 4/1), discoloration.
							SW(40%)	MEDIUM TO COARSE SAND, trace pebbles; poorly sorted ; subround to round; subprismoidal; loose; non-plastic; dry to moist; light gray to gray, (5Y 6/1).
10.0			8:9:9:8	10.0	1.4	0.0	SW	MEDIUM TO COARSE SAND AND GRAVEL; poorly sorted ; subangular to subround; subprismoidal; loose; non-plastic; dry to moist; light gray to gray, (5Y 6/1).

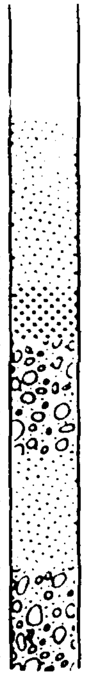
* Geotechnical Sample

BACKGROUND BORINGS

SOIL BORING NO.	BK-2
SUPERVISORY GEOLOGIST	D. VANWINKLE
LOG BOOK/PG No.	2/56
DRILLING STARTED	4-28-89
ABANDONMENT COMPLETED	4-29-89

JOE FOSS FIELD
SOIL BORING LOG

DRILLING COMPANY	LAYNE-WESTERN
RIG TYPE	HOLLOW-STEM AUGER



DEPTH (BLS)	LITHOLOGIC SYMBOLS	LAB SAMPLE NUMBER	BLOW COUNT	TOP OF SAMPLE ('BLS)	RECOVERY	HNU	SOIL TYPE (USCS)	LITHOLOGIC DESCRIPTION
0.0								
5.0			13:23:33:31	5.0	2.0	NR	SW	COARSE TO VERY COARSE SAND, some fine to medium pebbles; poorly sorted; subround to round; spherical, trace discoidal, prismoidal; loose; non-plastic; moist; pale brown, salt and pepper, (10YR 6/3).
10.0			13:16:20:19	10.0	1.7	NR	SW(50%)	COARSE TO VERY COARSE SAND, trace fine to medium pebbles; poorly so ted; subround to round; spherical, trace discoidal, prismoidal; loose; n n-plastic; wet; pale brown to brown, (10YR 6/3); water encountered at approx. 10 feet BLS.
							SP(50%)	MEDIUM SAND, trace coarse to very coarse sand; well sorted; subangular to round; spherical; loose; non-plastic; wet; grayish brown to dark grayish brown, (2.5Y 4.5/2)
15.0		BK-2-15	12:20:24:28	15.0	1.6	NR	GW	FINE TO MEDIUM PEBBLY GRAVEL, some very coarse sand; very poorly sorted; subround to round; spherical, some discoidal, trace prismoidal; loose; non-plastic; saturated; grayish brown, (2.5Y 5/2).
20.0		BK-2-20	9:11:23:48	20.0	2.0	NR	SW	COARSE TO VERY COARSE SAND, some fine pebbles; poorly sorted; subround to round; spherical, some discoidal; loose; non-plastic; saturated; gray, (5Y 5/1) to light brownish gray, (2.5Y 6/2).
25.0		BK-2-25	8:23:29:41	25.0	2.0	NR	GW	FINE TO MEDIUM PEBBLY GRAVEL, some very coarse sand; very poorly sorted; subangular to round; spherical, some discoidal, trace prismoidal; loose; non-plastic; saturated; grayish brown, (2.5Y 5/2).

NR-Not Recorded

SOIL BORING NO.	BK-3	JOE FOSS FIELD	DRILLING COMPANY: LAYNE-WESTERN
SUPERVISORY GEOLOGIST	D. VANWINKLE	SOIL BORING LOG	RIG TYPE: HOLLOW-STEM AUGER
LOG BOOK/PG No.	2/58		
DRILLING STARTED	4-28-89		
ABANDONMENT COMPLETED	4-29-89		

DEPTH (BLS)	LITHOLOGIC SYMBOLS	LAB SAMPLE NUMBER	BLOW COUNT	TOP OF SAMPLE ('BLS)	RECOVERY	HNU	SOIL TYPE (USCS)	LITHOLOGIC DESCRIPTION
0.0		BK-3-0.5	5:8:10:12	0.5	1.0	NR	ML(40%)	CLAYEY SILT; soft; slightly plastic; moist; very dark grayish brown, (10YR 3/2).
							ML(60%)	SILT; traces of caliche; firm; non-plastic; dry; grayish brown, (10YR 5/2).
5.0		BK-3-5	10:15:9:10	5.0	2.0	NR	ML	FINE TO MEDIUM SANDY SILT (sand layers); firm; non-plastic; dry; light grayish brown to grayish brown, (10YR 5.5/2), iron oxide stains.
20.0		BK-3-20	10:15:15:20	20.0	1.0	NR	SW	VERY COARSE SAND, trace fine to medium pebbles; very poorly sorted; subround to round; spherical, some discoidal, trace prismoidal; loose; non-plastic; saturated; grayish brown, (10YR 5/2).

NR-Not Recorded

APPENDIX B:

SHALLOW SEISMIC SURVEY REPORT

<u>SEISMIC REFLECTION SURVEY</u>

for

<u>SCIENCE APPLICATIONS INTERNATIONAL CORP.</u>

****

Joe Foss Field,
Sioux Falls, South Dakota

January 3, 1989

by

Minnesota Geophysical Associates, Inc.
14124 Ivywood Street Northwest
Andover, Minnesota 55304

STATEMENT OF PURPOSE

The contents of this report are for use by Science Applications International Corporation (SAIC). The data contained herein, as well as all interpretations, inferences, and conclusions drawn reflect MGA's commitment to the highest professional standards. Interpretations are not facts, however, and may be subject to unavoidable errors. Consequently, MGA cannot assume any liability for decisions made on the basis of these data.

All data, including this document, are the property of the client, and may be used in the normal practice of their business. Publication of any of this material in professional journals, presentations, or any other public forum may have some bearing on the professional reputations of MGA and our staff. Consequently, any use of interpretations, conclusions, or other information which reflects the exercise of our professional judgement in any public forum must receive prior written authorization from MGA.

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SUMMARY

A five-line seismic reflection survey was performed for Science Applications International Corporation (SAIC), by Minnesota Geophysical Associates (MGA) at Joe Foss Field in Sioux Falls, South Dakota between November 30 and December 2, 1988. The object of the survey was to 1) determine bedrock depth, and 2) better characterize the overburden stratigraphy.

Seismic reflection was chosen as the optimum geophysical method for this study because of its capability for high resolution both vertically and horizontally. A total of 250 field records were obtained, and the data reduced using MGA's seismic processing system. The resulting seismic reflection cross-sections are shown in Figures 3 through 7.

Three distinct reflection events were interpreted:

1) The water table produced a strong event across all lines, at an estimated depth of about 15 feet.

2) A buried alluvial channel was identified beneath the first event and above bedrock. The trend and approximate depth of the channel are shown in Figure 2.

3) An apparent bedrock reflector was identified and mapped. Figure 1 shows contours of bedrock depth based on the seismic interpretation. While the depth was surprising (bedrock had been expected at around 45 feet) the results are corroborated by the refraction data, which indicate a minimum depth of 90 feet to a 12,000 foot/second layer. Previous work in the area has shown velocities of 12,000 to 18,000 feet/second for the Sioux Formation.

Data quality for the survey was mediocre, due to high ambient noise levels and highly variable near-surface material. Consequently, depth estimates from the survey are not as reliable as they might otherwise be. Some conclusions can be confidently drawn, however, such as the existence and trend of the channel, the relatively deep bedrock, and the general configuration of the bedrock surface.

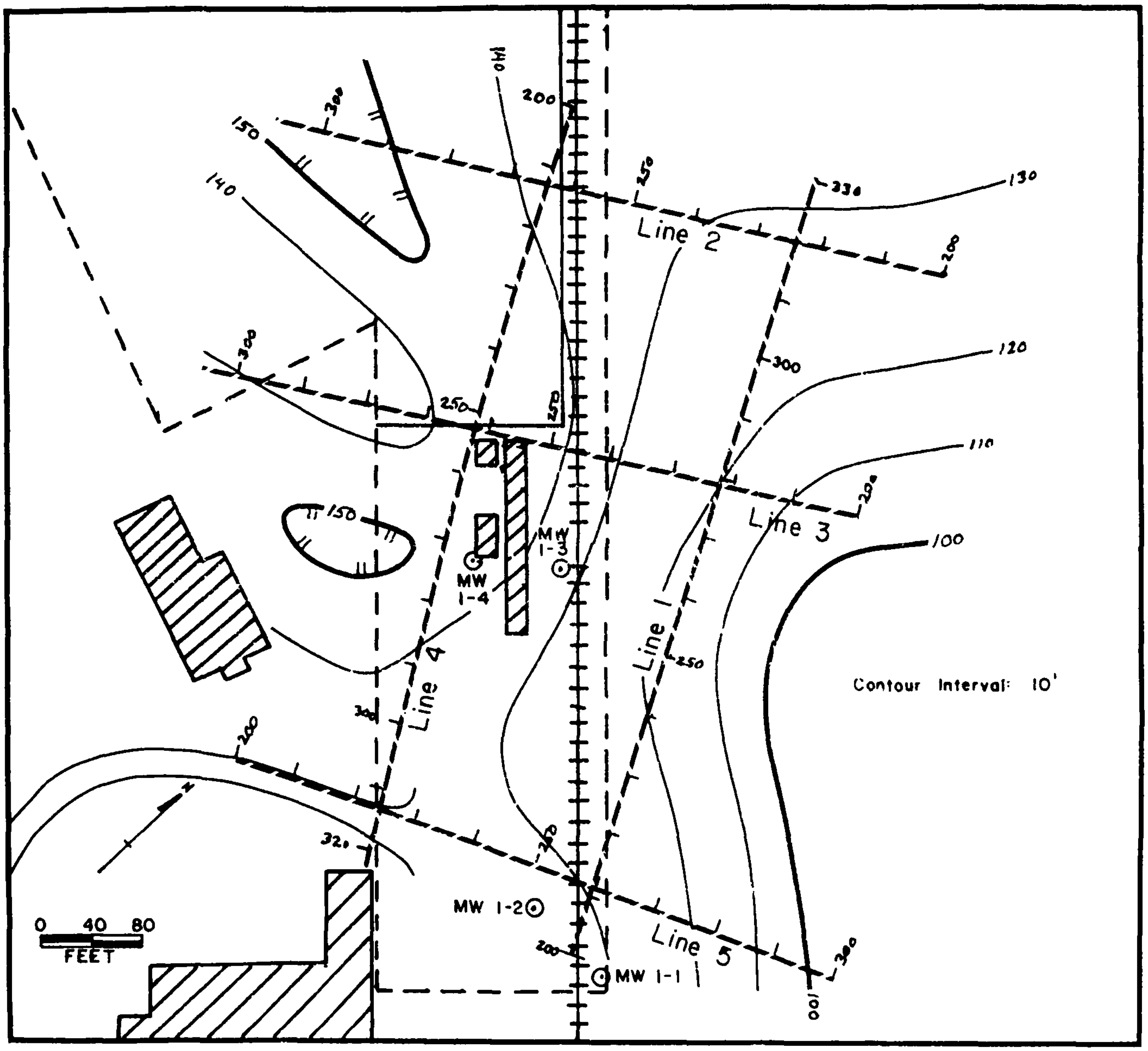

FIGURE 1: Joe Foss Field Seismic Reflection Line Locations with Bedrock Depth Contours

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INTRODUCTION

A five-line seismic reflection survey was performed for Science Applications International Corporation (SAIC), by Minnesota Geophysical Associates (MGA) at Joe Foss Field in Sioux Falls, South Dakota between November 30 and December 2, 1988.

Goals

The object of the seismic study was two-fold:

1) determine the depth and configuration of bedrock;
2) characterize, as far as possible, the stratigraphy of the overburden.

Survey Design

Several phone discussions were held between Phil Davis of MGA and Eric Gibson of SAIC between February 23 and November 26, 1988 regarding the use of seismic methods at the Sioux Falls site. Both seismic refraction and reflection were considered. Seismic refraction alone was ruled out for several reasons, including highly variable near-surface velocities, probably velocity inversions, the necessity of longer geophone spread lengths, and the generally more limited information potential. In addition to its advantages, seismic reflection would include basic refraction information to aid in velocity interpretation.

Five seismic lines were planned as follows:

1) two northwest-southeast trending lines about 480 feet in length;

2) three southwest-northeast lines about 360 feet in length.

Field logistics necessitated some adjustment in the planned program. All five lines were lengthened, and some locations were changed to avoid buildings and other obstacles. The final configuration of seismic lines is shown in Figure 1.

Methods

A discussion of the seismic method is contained in Appendix A. Briefly, seismic methods use measurements of sound waves to determine subsurface structure. Seismic reflection is much like sonar: the time it takes for an echo from a subsurface interface to reach a surface receiver, when compensated for acoustic velocity and offset distance between source and receiver, gives a measure of the depth to that interface. Seismic refraction uses measurements of travel times, to receivers at increasing

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horizontal offsets, of sound waves traveling along the upper surface of a subsurface layer to measure both the velocity and depth of that layer. Generally, refraction is better suited to shallow targets, while reflection, because of the abundance of near-surface noise, works better at depth.

DATA ACQUISITION

A two-person field crew was mobilized to the Sioux Falls site on November 29, 1988, to begin seismic acquisition the following day. Copies of the field observer's notes are in Appendix B.

Field Procedures

Seismic field acquisition involves three basic elements:

1) a source of acoustic energy,
2) geophones, or receivers, and
3) a seismograph to record the data.

The choice of seismic source depends on various factors, including depth of target, required resolution, and field conditions. MGA uses three main seismic sources:

1) the "Buffalo Gun", a device which fires 12-gauge shotgun blanks into an augered hole 2 inches wide by 2 feet deep;

2) the "Elastic Wave Generator" (EWG), a mechanized sledgehammer, which uses large elastic bands to accelerate a 300 pound hammer against a steel base plate; and

3) a manual 10 or 12 pound sledgehammer swung against a small aluminum baseplate.

The gun is generally the preferred source for shallow reflection because of its simplicity and very short pulse duration, allowing slightly higher resolution. The EWG is preferable for deep data (greater energy than the gun), noisy conditions (ability to "stack" several shots), or areas where augering is difficult. "Stacking" involves repeated source pulses at the same location; the data from all pulses are summed, enhancing any source-generated energy, while cancelling random energy such as wind, traffic, etc. The sledgehammer is reserved for situations where neither of the other sources is usable. All three sources were used in the Sioux Falls survey at various times.

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The seismic receivers used by MGA are 24 geophones, each planted into the ground with a three-inch spike and connected to the seismograph via two 12-channel cables. On asphalt or other hard surfaces, the spikes are replaced by steel baseplates which rest on the ground surface. The seismograph is a Bison Instruments GeoPro 8024 with internal digital data storage. The data are later downloaded to floppy disks for computer processing.

Twelve reflection records were acquired with each 24-geophone spread, with shot locations beginning at the end of the spread and continuing at ten foot intervals to the center of the spread. At this point, the near twelve-channel cable was redeployed beyond the farther cable in leapfrog fashion, and the procedure was repeated with the new spread.

Site Conditions

Field conditions were difficult. Snow and mud contributed to equipment problems, necessitating frequent cleaning and drying of equipment. Noise from aircraft and truck traffic caused delays, as well as deteriorating data quality.

As expected, disturbed near-surface conditions were evident in the data. Lines which crossed concrete surfaces were afflicted with surface-borne noise, further reducing data quality. Buried tanks or other artificial fill material caused some diffraction of seismic waves. (One apparent buried tank is evident on Line 5.) Concrete and asphalt surfaces also prevented the drilling of shot holes required for the Buffalo Gun, necessitating the use of a surface seismic source.

Production

In spite of the logistical difficulties, production rates were quite good. A total of 250 24-channel shot records were obtained over a three day period. Average daily production under good field conditions is about 50 records the first day in the field (due to initial surveying and testing), and 80 to 120 in subsequent days. Under more difficult conditions, production may drop substantially. Although requiring long hours, productivity under these adverse conditions was excellent.

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A summary of data production for the survey follows:

Line #	Total # records	Footage
1	60	600
2	44	440
3	42	420
4	62	620
5	42	420
Total	250	2500

"Footage" is based on a 10 foot shot interval, and is not necessarily the same as subsurface coverage on the processed lines. (The latter will normally be slightly greater).

DATA PROCESSING

Computer processing of seismic reflection data has until recently been restricted to large computers and large budgets. Recent advances in microcomputers have allowed the adaptation of this software for smaller-scale operations. MGA uses a software package produced by the Kansas Geological Survey. MGA has further adapted this software to account for the more complicated wave patterns encountered in shallow reflection records.

Five processes form the core of the seismic processing sequence:

1) sorting,
2) gain correction,
3) normal moveout (NMO) correction,
4) stacking, and
5) filtering.

Sorting involves reordering the individual seismic traces from field records into common midpoint groups. A field record consists of a series of traces from a common shot, with receivers at varying distances. Traces from different shots with common source-receiver midpoints are assumed to represent the same subsurface location. Each common midpoint (CMP) gather consists of traces with varying offsets, each from a different shot-receiver pair. (The term "common depth point", or CDP, is widely used in the seismic industry. As depth points are related to subsurface structure as well as source-receiver configuration, the term "common midpoint" is more accurate, and is gaining in recognition and usage. The two are otherwise synonymous.)

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Gain correction compensates for the decrease in amplitude of events with travel time. Methods vary, but the most common involve some kind of automatic gain control (AGC), where event amplitudes are increased or decreased to fall within some limited range.

Normal moveout correction compensates for the increase in travel time with horizontal offset. Using input velocities, a correction can be determined which brings a given event up in time to a point equivalent to a vertical travel path. If the correction is properly applied, a given event will occur at the same travel time on all traces within a CMP gather, and will appear "flat". Other events, such as multiple reflections, diffractions, and coherent noise will not be corrected to a flat event, and will be attenuated in the stacking process.

"Stacking" is simply the summing of all traces within a CMP gather into a single trace. Events which have been corrected to flat will be significantly enhanced, while others will be reduced in relative amplitude. The final seismic section is simply a series of such summed traces from adjacent CMP locations.

High-frequency noise can be further reduced by applying a high-cut digital filter. In the present survey, a band-pass filter was applied with a low-cut frequency of 40 hertz and a high-cut frequency of 600 hertz.

In practice, seismic reflection processing can be extremely tricky. It requires experience to correctly identify reflectors, analyze velocities, and subsequently interpret the resulting seismic section. Shallow reflection is more difficult than deep reflection, and requires even more "hands on" processing. When properly done, however, a seismic section provides a wealth of information not available from any other method.

INTERPRETATION

General Aspects of Reflection Interpretation

The fundamental feature of a reflection seismic section is the event. An event is any sequence of wavelets which are coherent across a succession of traces, forming a discernible line. Events may be reflections or spurious events. They may be flat, dipping, or undulating; high amplitude and "bright", or fuzzy and barely coherent. When real events are nicely coherent, the seismic section has the appearance of a geologic cross-section, with a few critical differences.

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Types of spurious events include:

* multiple reflections, or waves which have traversed a vertical distance two or more times;

* diffractions, or reflections from a small, sharp feature which scatter in all directions; these take on a characteristic hyperbola, or diffraction "umbrella";

* coherent noise, such as a steady vibration from off one end of the line, which stacks in a coherent fashion.

Meaningful geologic results require that reflection events be converted from seismic travel time to depth. This may be the most critical aspect of reflection interpretation, as the computed depth depends entirely on the acoustic velocities used. When possible, direct measurement of seismic velocity using wells and downhole geophones provides the most accurate conversion possible. Refraction velocities are useful, although velocity inversions and hidden layers can cause problems. Geology can be a good guide to seismic velocities, especially when coupled with refraction data. Unconsolidated materials, for example, have a fairly limited range of velocities. Saturated sediments will show higher velocities than dry material. Knowledge of the type of bedrock can make a substantial difference in velocity estimates. Normally, a combination of these techniques provides the most reliable depth conversion.

The travel time of a particular seismic reflection event is the onset time. This can be very confusing, as the maximum energy of the event, which is its clearest expression, typically occurs 5 to 20 milliseconds after the onset time.

Survey Interpretation

The final processed seismic reflection sections are shown in Figures 3 through 7. The numbers across the top are arbitrary station numbers, and refer to the locations on the plan view maps. The numbers on the left side are two-way travel times in milliseconds (ms), and can be used to convert to depths based on interpreted velocities. The depth scale on the right is approximate, and is based on a model of 15 feet of dry sediment (velocity = 1200 feet/second) overlying saturated sediments (velocity = 5000 feet/second). Any deviations from this velocity distribution will result in depth conversion errors.

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Three principal events have been identified on the seismic sections, based on refraction velocities and background stratigraphic information. These are, in descending order, the water table (or top of saturated sediments), the base of an apparent alluvial channel, and the top of bedrock, probably Sioux quartzite.

Water table:

A quick interpretation of refraction arrivals indicated a two-layer model, with a faster layer (5000-6000 ft/sec) at about 15 feet in depth beneath a slower layer (1000-1200 ft/sec). The faster velocity is similar to that of water (about 5000 ft/sec) and almost certainly represents the top of saturated sediments. The reflector identified in Figures 3 through 7 may actually be a velocity-corrected refraction arrival, and not a reflector proper. It is a valid seismic event nonetheless.

Buried channel:

While not as apparent as some channels, there are several strong indications of this feature. In particular, the criss-crossing events on Line 3 (Figure 5) are diagnostic of a trough-shaped feature, the extra limbs resulting from non-vertical reflections. The trend of the channel is clear, and is illustrated, along with depth contours, in Figure 2. Because of the relatively mediocre data quality (due to conditions discussed above), the interpreted depths are at best rough approximations. Based on the geologic setting, the channel is probably cut into preexisting glacial till.

Bedrock reflector:

Figure 1 shows depth contours on the bedrock surface. This is surprising primarily because of the apparent depth of the Sioux Formation, which had been expected at about 45 feet. Again, the mediocre data quality makes the exact onset time difficult to determine, and these depths may be significantly in error. There is confirmation of the relative depth of bedrock, however, in the refraction data. Quartzite typically has a very fast seismic velocity. In another seismic survey in the Sioux Falls area, MGA measured velocities of 12,000 to 18,000 feet/second from the Sioux Formation. In the present survey, there was no such event appearing as a refraction arrival at offsets of up to 235 feet. Using a minimum crossover distance of 240 feet and a velocity of 12,000 feet/second, the shallowest depth for the Sioux quartzite would be about 90 feet.

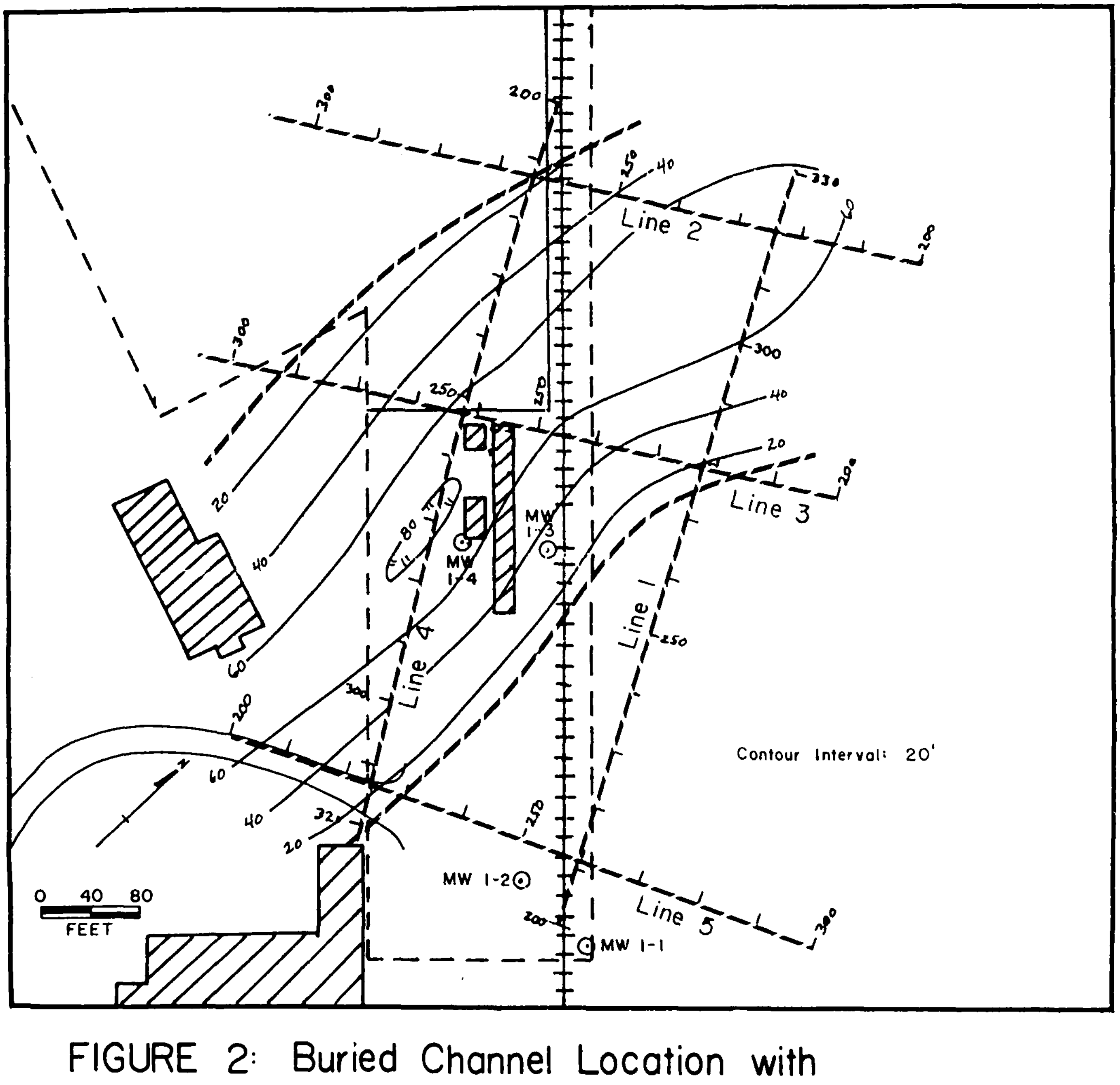

FIGURE 2: Buried Channel Location with Approximate Depth Contours

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It is possible that bedrock is not a high-velocity material, either a different formation than anticipated, or a significantly weathered Sioux Formation. If this is the case, the event shown as bedrock may be a reflector within the bedrock, perhaps the base of the weathered zone. If this is the case, both refraction velocities and the lack of a strong reflector suggest that bedrock velocities are very close to those of the overburden, perhaps 5000 to 7000 feet/second.

<u>Other features</u>:

An interesting event appears on Line 5 (Figure 7) near station 234. The feature, labeled "buried tank?" is a classic diffraction "umbrella", resulting from non-vertical reflections from a point source. Since buried tanks are known to frequent the site, this is the most likely cause. The drop in the water table reflector beneath the diffraction represents an increase in travel time due to a lower velocity above, rather than an actual lowering of the water table.

The relatively high level of noise in the shallowest section (above 20 milliseconds) probably results from scattering from numerous near surface refractors, such as buried tanks, building foundations, etc.

CONCLUSIONS

The seismic reflection survey over the Joe Foss Field site was successful in addressing the major goals of the project. These included:

1) Mapping the top of bedrock, apparently substantially deeper than was originally thought; and

2) Locating a buried alluvial channel in the overburden, as well as establishing the trend of the channel.

Because of mediocre data quality, the depth estimates are rough approximations only. Well data should be reviewed to better define the stratigraphy of the channel. Follow-up borings may be helpful for further stratigraphic information, and possibly to confirm the depth to bedrock.

The Sioux Falls seismic survey was difficult, both in acquisition and reduction of the data. Valid results were obtained, however, and the data will provide information which can be correlated with existing and future data to further the understanding of the site.

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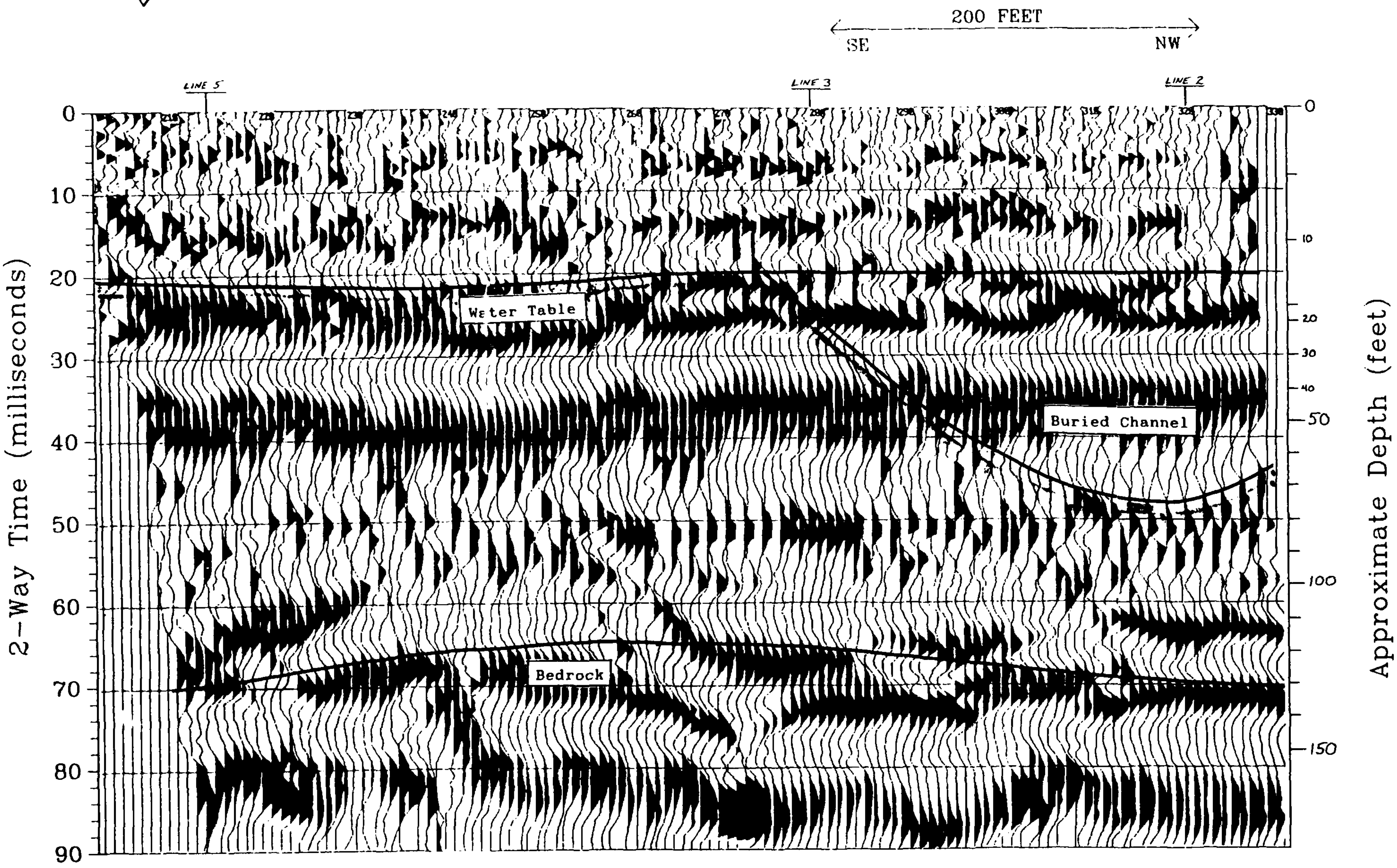
Figure 3: Seismic Reflection Line 1
Joe Foss Field, Sioux Falls, S. Dakota
December 2, 1988



MINNESOTA GEOPHYSICAL ASSOCIATES

Figure 4: Seismic Reflection Line 2
Joe Foss Field, Sioux Falls, S. Dakota
December 2, 1988

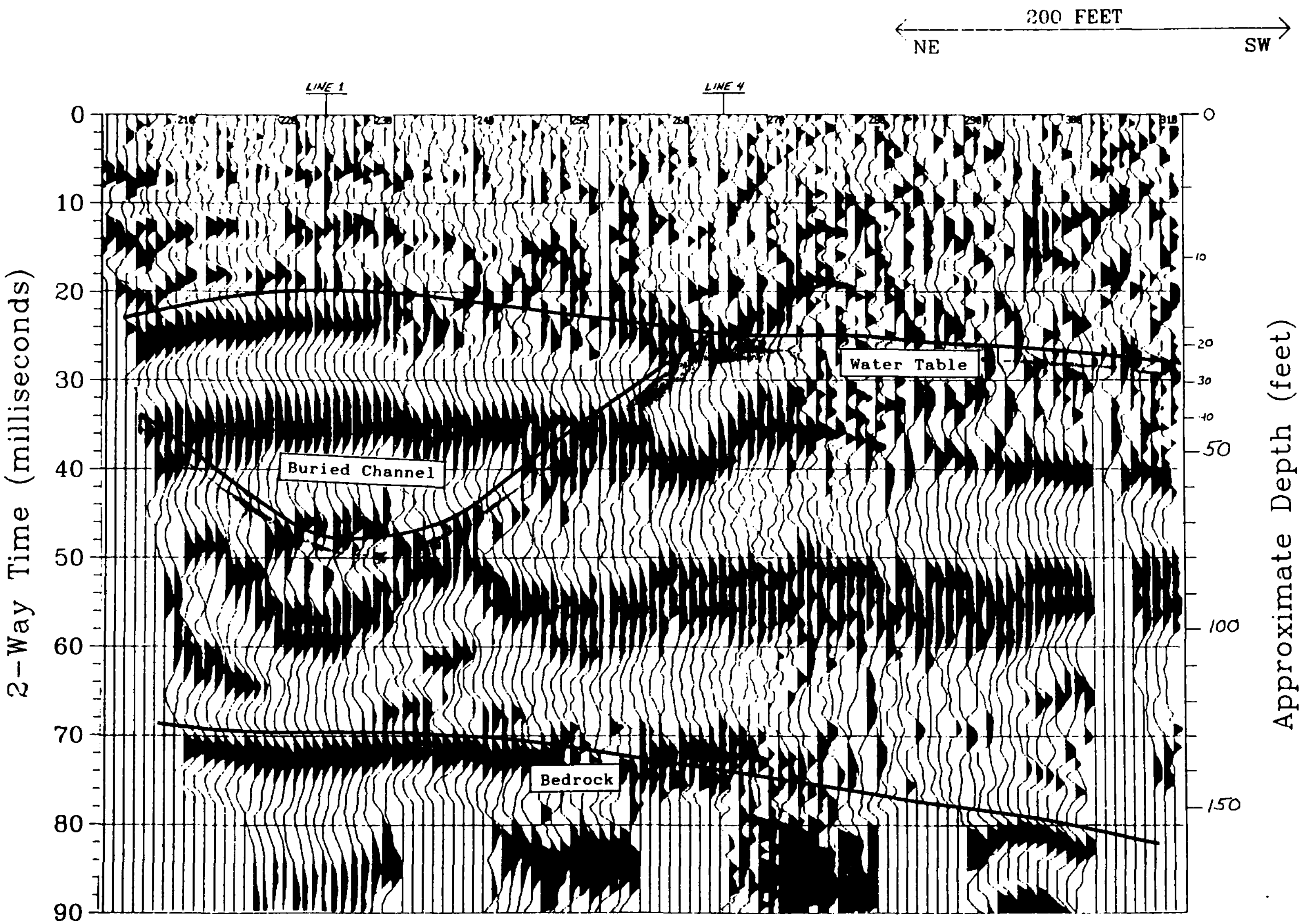


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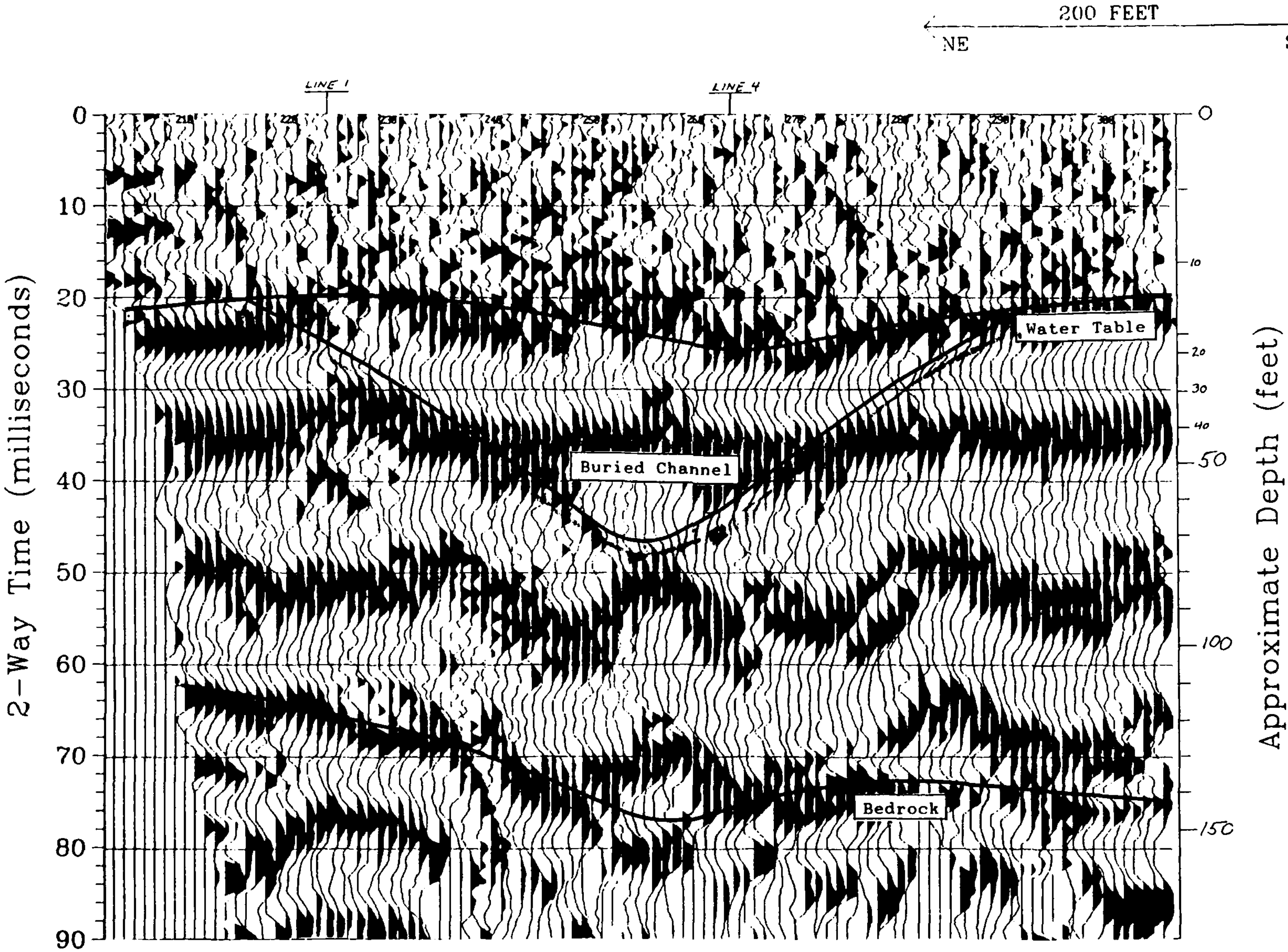
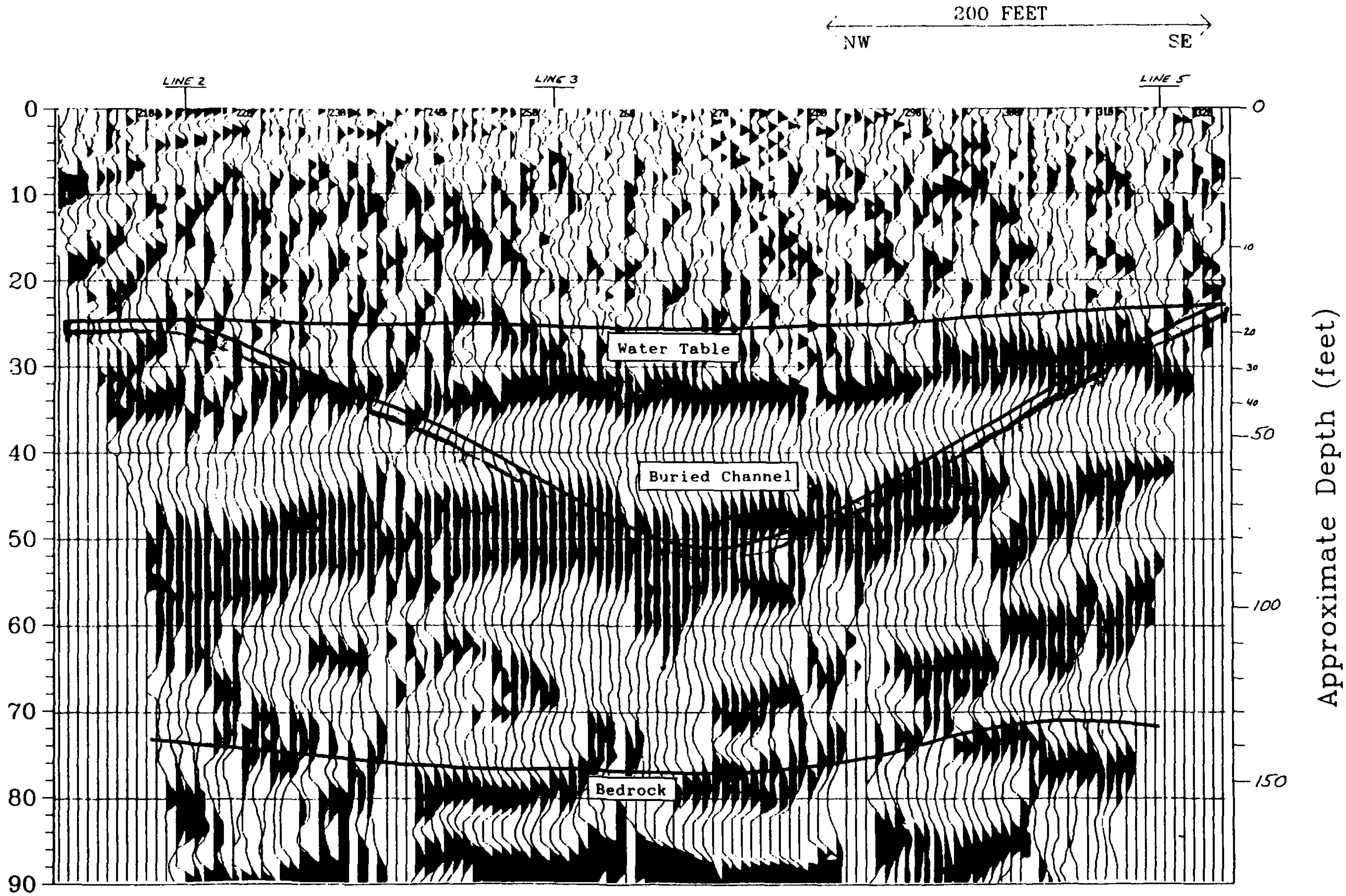
Figure 5: Seismic Reflection Line 3
Joe Foss Field, Sioux Falls, S. Dakota
December 2, 1988



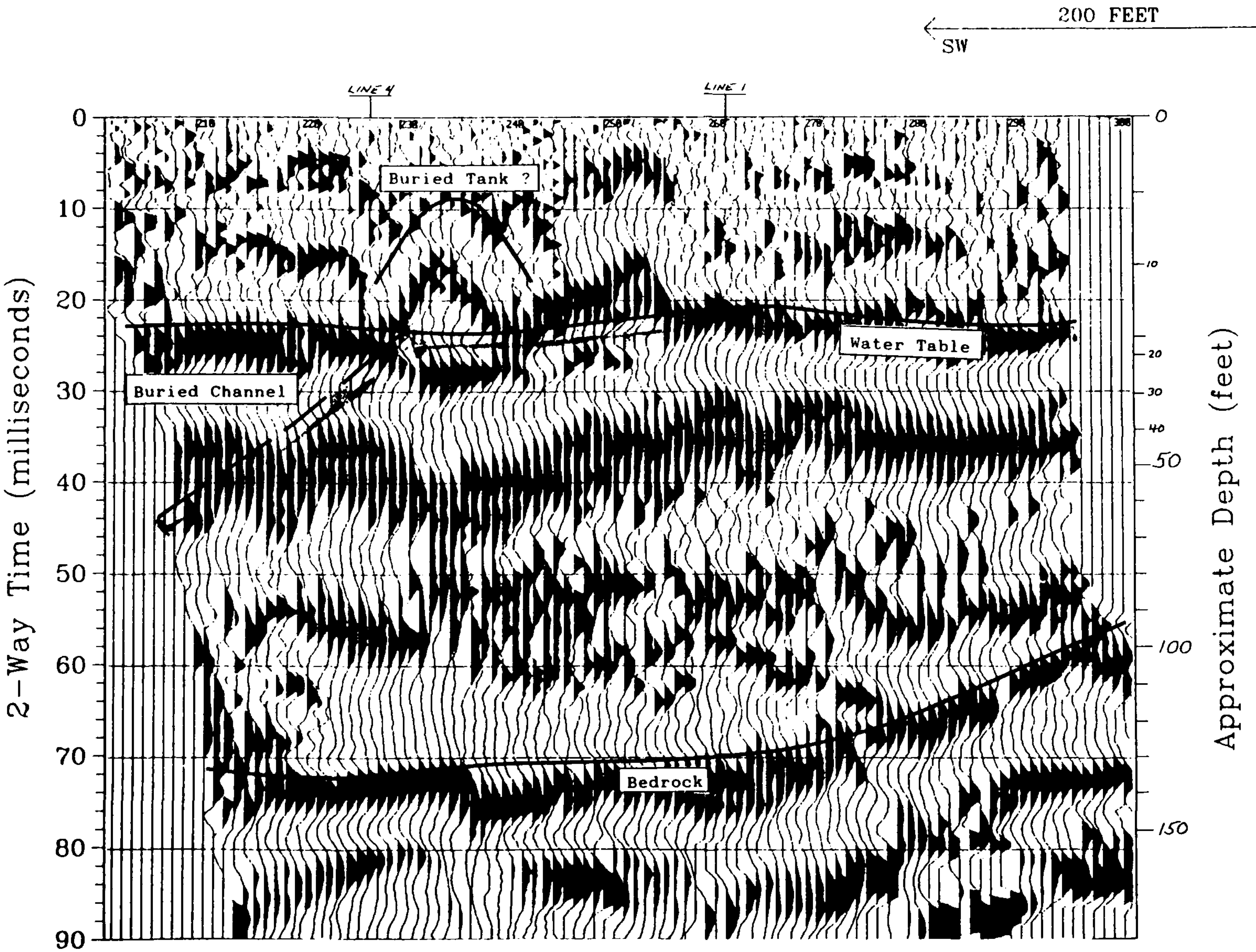
MINNESOTA GEOPHYSICAL ASSOCIATES

Figure 6: Seismic Reflection Line 4
Joe Foss Field, Sioux Falls, S. Dakota
December 2, 1988



MINNESOTA GEOPHYSICAL ASSOCIATES

Figure 7: Seismic Reflection Line 5
Joe Foss Field, Sioux Falls, S. Dakota
December 2, 1988



APPENDIX A:

Overview of the Seismic Method

A Brief Overview of

SEISMIC EXPLORATION

Introduction

"Seeing" with sound is a familiar concept. Bats do it. Submarines do it. A blind person with a cane does it. In total darkness we can sense whether we are in a closed or open space by the sound of echoes from our footsteps.

Seismic exploration, in principle, is nothing more than a mechanized version of the blind person and his cane. In place of the tapping cane we have a hammer blow on the ground, or an explosion in a shallow hole to generate sound waves. And we "listen" with geophones, spring-mounted electric coils moving within a magnetic field. These coils generate electric currents in response to ground vibrations. Careful analysis of the received sound wave can tell us whether it is a direct, surface-borne wave, one reflected from some subsurface geologic interface, or a wave refracted along the top of that interface. Each of these waves tells us something about the geology of the subsurface.

Seismic Reflection

Reflections of sound waves from subsurface boundaries arrive at the geophones some measurable time after our source pulse. If we know the speed of sound in the earth, we can convert that seismic travel time to depth. And by measuring the arrival time at successive surface locations we can produce a profile, or cross-section of seismic travel times. A simple concept.

In practice, the speed of sound in earth materials varies enormously. Dry, unconsolidated sand might carry sound waves at roughly air velocity, or about 1100 feet per second (fps). At the other extreme, unfractured granite bedrock has an acoustic velocity in excess of 18,000 fps. And the more layers there are between the surface and the layer of interest, the more complicated the velocity picture.

Various methods are used to estimate subsurface velocities. In shallow reflection work, the most common means is to use refraction velocities. Others include lowering a geophone down a borehole and measuring direct travel-times from the surface to the geophone, estimating velocities from known lithologic parameters, and examining the difference in reflection time at various horizontal offsets. Each of these methods has its advantages. Generally, a combination of methods will give the best results.

Seismic Refraction

When a sound wave crosses an interface between layers of two different velocities, the wave is refracted. That is, the angle of the wave leaving the interface will be altered from the incident angle, depending on the relative velocities and the incident angle. Going from a low-velocity layer to a high-velocity layer, a wave at a particular incident angle will be refracted along the upper surface of the lower layer. As it travels, the refracted wave spawns upgoing waves in the upper layer, which impinge on the surface geophones. The difference in travel time of this arrival between geophones depends on the velocity of the lower layer. If the surface is plane and level, the refraction arrivals form a straight line whose slope corresponds directly to that velocity.

Sound moves faster in the lower layer than the upper, so at some point, the wave refracted along that surface will overtake the direct wave. This refracted wave is then the first arrival at all subsequent geophones, at least until it is in turn overtaken by a wave refracted along a still faster surface. In most cases, this first arrival is the easiest to identify on any particular trace. The combination of easy identification and comparitively simple, straight-line interpretation, makes seismic refraction one of the more popular shallow geophysical techniques.

Field Procedures

At Minnesota Geophysical Associates, we use a Bison Instruments "GeoPro" 24-channel seismograph. Input is recorded from 24 geophones (Mark Products L-40, 40-Hertz geophones), digitized, and stored internally in 8-bit format. The sound pulse is generated by one of three sources:

1) the Bison Elastic Wave Generator (a rubber-band accelerated weight drop);

2) the "Buffalo Gun", a device which fires 12-gauge shotgun blanks in a two-inch diameter, two-foot deep augered hole;

3) a 10 or 12 pound sledgehammer.

The choice of seismic sources depends on various factors, including depth of the target horizon, surface conditions, and ambient noise levels.

Typically, the 24 geophones are located at equal intervals (usually from 5 to 20 feet) along the profile line. The source location is usually off end, but may be at some point within the geophone spread. The arrangement of source and geophones depends on the nature of the survey. For seismic reflection work, we generally take shot records at twelve different locations at uniform intervals, beginning at one end ending at the center of the spread. This procedure may vary according to the requirements of the individual survey.

For refraction work, shots are taken at both ends of the spread, and often additionally at some distance off either end. In reflection surveys, refraction shots are sometimes taken at one or two locations off the opposite end of the geophone spread from the reflection shots, to complement the reflection data.

Data Processing

A seismic reflection section is, in principle, a series of seismic traces recorded by a geophone at the same location as the shot. Since the geophones are offset from the shot at varying distances, each trace must be time-corrected for that offset. The correction depends on the layer velocities. If the correction is accurate, a given reflection is moved up the trace to the position it would have were the source and receiver coincident. Using the above field procedure, twelve individual traces, of various source-receiver offsets, will have a common midpoint. These twelve traces, after correction, are summed to produce one common depth point, or CDP trace. The resulting summed traces are then displayed as a single seismic cross-section.

Each seismic trace generated by the GeoPro contains 959 individual samples. With each shot generating 24 traces, a typical seismic line may contain several million individual samples. Clearly, the processing of such volumes of data must be done on a computer. Until recently, only the oil industry had systems capable of processing seismic reflection data. At MGA, we have a system developed by the Kansas Geological Survey for IBM-compatible microcomputers. Augmented by several programs developed by MGA, we now have a seismic processing system tailored to the unique problems encountered in high-resolution seismic work. We believe this system to be unmatched in the industry.

Seismic refraction data can be interpreted in several ways. The simplest approaches assume a series of plane, dipping layers. While effective under many circumstances, this method is not suited to undulating refractors. The Generalized Reciprocal Method (GRM) of refraction interpretation goes beyond the plane-layer assumption, producing a cross section which allows for undulations in the refracting surface. When possible, we combine GRM with seismic reflection to produce the most comprehensive high-resolution seismic interpretation available.

Summary

Seismic exploration is a powerful geophysical technique. In the petroleum industry it has achieved unparalleled success; very few exploratory wells are drilled without first acquiring seismic data. With the advent of microelectronics, seismic reflection is now available on a smaller, less expensive scale. MGA has the capability of acquiring detailed, high-resolution seismic images of the near-surface geology. Applications such as environmental geology, groundwater investigations, structural engineering, and mining all stand to benefit from seismic techniques. At MGA, we intend to continue providing the most effective, state-of-the-art seismic exploration available.

APPENDIX B:

Field Observer's Notes

SEISMIC FIELD NOTES

PROJECT: Joe Foss Field | LOCATION: Sioux Falls SD | CLIENT: [illegible]

LINE: 1 | DIRECTION: S→N | DATE: [illegible] | OPERATOR: [illegible], MORRISON

Sta. Spacing: 10' | Source Type: [illegible] / [illegible]

REC #	SHOT Sta. #	Offset in	Offset off	Elevation shot	Elevation rec	RECEIVER Station # #1	Station # #24	COMMENTS	PS
1	100	-	-			123.5	100.5		0
2	101	-	-			"	"		1
3	102	-	-			"	"		2
4	103	-	-			"	"		3
5	104	-	-			"	"		4
6	105	-	-			"	"		5
7	106	-	-			"	"		6
8	107	-	-			"	"		7
9	108	-	-			"	"		8
10	109	-	-			"	"	[illegible] @ STN 109.5	
11	110	-	-			"	"		
12	111	-	-			"	"		
13	112	-				135.5	112.5		0
14	113	-	-			"	"		1
15	114	-	-			"	"		2
16	115	-	-			"	"		3
17	116	-	-			"	"		4
18	117	-	-			"	"		5
19	118	-	-			"	"		6
20	119	-	-			"	"		7
21	120	-	-			"	"		8
22	121	-	-			"	"		
23	122	-	-			"	"		
24	123	-	-			"	"		

SEISMIC_FIELD_NOTES

PROJECT: Joe Foss Field	LOCATION: Sioux Falls S.D.	CLIENT: SAIC	
LINE: 2	DIRECTION: S → N	DATE: 11/30/88	OPERATOR: TRAEN, MARKS
Sta. Spacing: 10'	Source Type: Gun		

REC #	SHOT Sta. #	Offset in	Offset off	Elevation shot	Elevation rec	RECEIVER Station #1	RECEIVER Station #24	COMMENTS	PS
25	124	-	-			147.5	124.5		0
26	125	-	-			"	"		1
27	126	-	-			"	"		2
28	127	-	-			"	"		3
29	128	-	-			"	"		4
30	129	-	-			"	"		5
31	130	-	-			"	"		6
32	131	-	-			"	"		7
33	132	-	-			"	"		8
34	133	-	-			"	"		
35	134	-	-			"	"		
36	135	-	-			"	"		
37	136	-	-			159.5	136.5		0
38	137	-	-			"	"		1
39	138	-	-			"	"		2
40	139	-	-			"	"		3
41	140	-	-			"	"		4
42	141	-	-			"	"		5
1A	142	-	-			"	"	12-1-88	6
2A	143	-	-			"	"		7
3A	144	-	-			"	"		8
4A	145	-	-			"	"		
5A	146	-	-			"	"		
6A	147	-	-			"			

SEISMIC_FIELD_NOTES

PROJECT: [illegible]	LOCATION: [illegible]	CLIENT: SAIC
LINE: 1	DIRECTION: [illegible]	DATE: [illegible]
OPERATOR: [illegible] Morrison		
Sta. Spacing: 10'	Source Type: [illegible]	

REC #	SHOT Sta. #	SHOT Offset in	SHOT Offset off	SHOT Elevation shot	SHOT Elevation rec	RECEIVER Station # #1	RECEIVER Station # #24	COMMENTS	PS
7A	148	-	-			[illegible]	148.5	snow removal equipment	0
8A	149	-	-			"	"	working off EOL	1
9A	150	-	-			"	"		2
10A	151	-	-			"	"		3
11A	152	-	-			"	"		4
12A	153	-	-			"	"		5
13A	154	-	-			"	"		6
14A	155	-	-			"	"		7
15A	156	-	-			"	"		8
16A	157	-	-			"	"		
17A	158		-			"	"		
18A	159	-	-			"	"		
		END OF LINE 1							
LINE 1 STN 159.5 ⊥ LINE 2 STN 111.5									
		BEGIN LINE 2				E → W		Source: GUN	
19A	100	-	-			123.5	100.5		0
20A	101	-	-			"	"		1
21A	102	-	-			"	"		2
22A	103	-	-			"	"		3
23A	104	-	-			"	"		4
24A	105	-	-			"	"		5
25A	106	-	-			"	"		6
26A	107	-	-			"	"		7
27A	108	-	-			"	"		8

SEISMIC_FIELD_NOTES

PROJECT: Joe Foss Field	LOCATION: Sioux Falls S.D.	CLIENT: SAIC
LINE: 2	DIRECTION: E → W	DATE: 12/01/92
OPERATOR: TRAEN/MORRISON		
Sta. Spacing: 10'	Source Type: GUN	

REC #	SHOT Sta. #	Offset in	Offset off	Elevation shot	Elevation rec	RECEIVER Station # #1	Station # #24	COMMENTS	PS
28A	109	-	-			123.5	100.5	Progressing towards	
29A	110	-	-			"	"	patio, storage Area	
30A	111	-	-			"	"		
31A	112	-	-			135.5	112.5	Fence @ STN 127.5	0
32A	113	-	-			"	"	STN 132.5 - 135.5 [illegible]	1
33A	114	-	-			"	"		2
34A	115	-	-			"	"		3
35A	116	-	-			"	"	[illegible]	4
36A	117	-	-			"	"	[illegible]	5
37A	118	-	-			"	"		6
38A	119	-	-			"	"		7
39A	120	-	-			"	"		8
40A	121	-	-			"	"		
41A	122	-	-			"	"		
42A	123	-	-			"	"		
43A	124	-	-			147.5	124.5	No Energy EOL	0
44A	125	-	-			"	"	(max. Gain)	
45A	126	-	-			"	"		
46A	127	-	-			"	"	STN 129.75 in middle of RR tk	
47A	128	-	-			"	"	STN 144.5 on hollow Cinder ~~block pipe cavern~~	
48A	129	-	-			"	"		
49A	130	-	-			"	"		
50A	131	-	-			"	"	Noise bet 144.5 + 145.5	
51A	132	-	5'			"	"	[illegible]	

SEISMIC_FIELD_NOTES

PROJECT: [illegible]	LOCATION: [illegible]	CLIENT: SAIC
LINE. [illegible]	DIRECTION: E → W	DATE: [illegible]
OPERATOR: TRAEN, MORRISON	Sta. Spacing: [illegible]	Source Type: [illegible]

REC #	SHOT Sta. #	Offset in	Offset off	Elevation shot	Elevation rec	RECEIVER Station # #1	Station # #24	COMMENTS	PS
52A	133	-	3'			13?.5	104.5	[illegible]	
53A	134	-	3'			"	"	↓	
54A	135	-	3'			"	"		
		END	OF	LINE 2					
	START	LINE 3		E → W					
1B	100	-	-			103.5	100.5	GUN	0
2B	101	-	-			"	"	↓	1
3B	102	-	-			"	"	[illegible] Line 1 STN 139.3	2
4B	103	-	-			"	"		3
5B	104	-	-			"	"		4
6B	105	-	-			"	"		5
7B	106	-	-			"	"		6
8B	107	-	-			"	"		7
9B	108	-	-			"	"		8
10B	109	-	-			"	"		
11B	110	-	-			"	"		
12B	111	-	-			"	"	STN 121 Fence	
13B	112	-	-			135.5	112.5	STN 123.25 mid RR Track	
14B	113	-	-			"	"	STN 126.5 + 127.5 on drive Thru concrete (on Top of Northern ~~most~~ Tank)	
15B	114	-	-			"	"		
16B	115	-	-			"	"		
17B	116	-	-			"	"		
18B	117	-	-			"	"		
19B	118	-	-			"	"		

SEISMIC_FIELD_NOTES

PROJECT: [illegible]	LOCATION: [illegible]	CLIENT: SAIC
LINE: 3	DIRECTION: [illegible]	DATE: [illegible]
OPERATOR: [illegible]/Morris	Sta. Spacing: 10'	Source Type: [illegible]

REC #	SHOT Sta. #	Offset in	Offset off	Elevation shot	Elevation rec	RECEIVER Station # #1	Station # #24	COMMENTS	PS
20B	119	-	-			135.5	112.5		
21B	120	-	-			"	"		
22B	121	-	-			"	"		
23B	122	-	-			"	"		
24B	123	-	-			"	"		
25B	124	-	- skip 125 → 127			147.5	124.5	STN 125 on Top of	0
26B	128	-	-			"	"	a pumping platform	4
27B	129	-	-			"	"	STN 126 on Top of a	5
28B	130	-	-			"	"	storage Tank	6
29B	131	-	-			"	"	STN 127 on Top of a	7
30B	132	-	-			"	"	6' concrete 8" thick	8
31B	133	-	-			"	"	driveway	
		skip 134 + 135						STN 128 - 5' N of	
32B	136	-	-			159.5	136.5	pump STN 50 door (NE corner	1
33B	137	-	-	monitor well		[illegible]	is	STN 130 6' N of	2
34B	138	-	-	4' North		of	159.5	Pump station NE corner.	
35B	139	-	-	Fence (w		STN	117.5	STN 134 & 135 on	4
36B	140	-	-			"	"	cement driveways	5
37B	141	-	-			"	"	(10' N of asphalt)	6
38B	142	-	-			"	"	STN 138.75 Fence	7
39B	143	-	-			"	"		8
40B	144	-	-			"	"		
41B	145	-	-			"	"		
42B	146	-				"	"		

END OF LINE 3

SEISMIC_FIELD_NOTES

PROJECT: [illegible]	LOCATION: [illegible]	CLIENT: [illegible]
LINE: [illegible]	DIRECTION: [illegible]	DATE: [illegible]
OPERATOR: [illegible]	Sta. Spacing: [illegible]	Source Type: [illegible]

REC #	SHOT Sta. #	SHOT Offset in	SHOT Offset off	SHOT Elevation shot	SHOT Elevation rec	RECEIVER Station # #1	RECEIVER Station # #24	COMMENTS	PS
43C	136	-	4'			173.5	136.5	STN 151.5 - 153.5	0
1C	137	-	4'			"	"	on a 4' gravel pile	1
2C	138	-	4'			"	"	STN 136.5 - 147.5 base	2
3C	139	-	4'			"	"	plates, 148.5 - 159.5	3
4C	140	-	4'			"	"	spikes.	4
5C	141	-	4'			"	"		5
6C	149	-	0'			[illegible]	[illegible]	GUN	
7C	150	-	0'			"	"	GUN	
		[illegible]							
		[illegible]						[illegible]	
	LINE [illegible]		[illegible] 106.5			LINE 2 STN 132			
	LINE 4		STN 126 - 7			LINE 3 STN 131.3			
1D	100		4'			123.5	100.5		0
2D	101		"			"	"	[illegible]	1
3D	102		"			"	"		2
4D	103		"			"	"		3
5D	104		"			"	"	[illegible]	4
6D	105		"			"	"		5
7D	106		"			"	"		6
8D	107		"			"	"		7
9D	108		"			"	"		8
10D	109		"			"	"		
11D	110		"			"	"		
12D	[illegible]		"			"	"		

SEISMIC_FIELD_NOTES

PROJECT: [illegible]	LOCATION: [illegible]	CLIENT: [illegible]	
LINE: 4	DIRECTION: [illegible]	DATE: [illegible]	OPERATOR: [illegible]
Sta. Spacing: [illegible]	Source Type: [illegible]		

REC #	SHOT Sta. #	SHOT Offset in	SHOT Offset off	SHOT Elevation shot	SHOT Elevation rec	RECEIVER Station # #1	RECEIVER Station # #24	COMMENTS	PS
13D	112		4'			[illegible]	[illegible]	STN 100.5 - 104.5 spikes	0
14D	113		"			"	"	STN 105.5 - 123.5 plates	1
15D	114		"			"	"	STN 124.5 - 132.5 spikes	2
16D	115		"			"	"	STN 133.5 - 143.5 plates	3
17D	116		"			"	"	STN 144.5 - spikes	4
18D	117		"			"	"		5
19D	118		"			"	"	STN 127 - [illegible] from NW	6
20D	119		"			"	"	corner of Bldg 52	7
21D	120		"			"	"		8
22D	121		"			"	"		
23D	122		"			"	"		
24D	123		"			"	"		
25D	124		"			102.5	124.5		0
26D	125		"			"	"		1
27D	126		"			"	"		2
28D	127		"			"	"		3
29D	128		"			"	"		4
30D	129		"			"	"		5
31D	130		"			"	"		6
32D	131		"			"	"	new built up beneath	7
33D	132		"			"	"	Two plate Fresh oil Asphalt	
34D	133		"						
35D	134		"			"	"		
36D	135		"				"		

SEISMIC_FIELD_NOTES

PROJECT: [illegible]	LOCATION: [illegible]	CLIENT: SAIC
LINE: 4	DIRECTION: [illegible]	DATE: [illegible]
OPERATOR: [illegible]	Sta. Spacing: [illegible]	Source Type: [illegible]

REC #	SHOT Sta. #	Offset in	Offset off	Elevation shot	Elevation rec	RECEIVER Station #1	Station #24	COMMENTS	PS
37D	136		4'			[illegible]	136.5		0
38D	137		"			"	"		1
39D	138		"			"	"		2
40D	139		"			"	"		3
41D	140		"			"	"		4
42D	141		"			"	"		5
1 ~~43D~~	142		"			"	"	Flag on pavement	6
~~44D~~	[illegible]		"			"	"	Flag off pavement (Stn)	7
6 ~~45D~~	144		"			"	"		8
7 ~~46D~~	145		"			"	"		
8 ~~47D~~	146		"			"	"		
9 ~~48D~~	147		"			"	"		
10 ~~49D~~	148		"			TRA 11 161.5	148.5	STN 154 in middle of	0
1 ~~50D~~	149		5' [111	TRA dead	[illegible]	161.5]		Driveway (See entrance Gate)	
2 ~~51D~~	150		"	(TRA	1-10	dead)	"	STN 161.5 is 2' North of	2
3 ~~52D~~	151		"			"	main	Building outside & South	3
4 ~~53D~~	152		"			"	"	of Gate	4
5 ~~54D~~	153		"			"	"		5
6 ~~55D~~	154		"			"	"		6
7 ~~56D~~	155		"			"	"		7
8 ~~57D~~	156		"			"	"		8
9 ~~58D~~	157		"			"	"		
1E	158		"			"	"		
2E	159		"			"	"		

SEISMIC_FIELD_NOTES

PROJECT: Joe Foss Field	LOCATION: [illegible]	CLIENT: OHIC
LINE: 4	DIRECTION: N → S	DATE: 10/02/84
OPERATOR: Tarch/Morrison	Sta. Spacing: 10'	Source Type: [illegible]

REC #	SHOT Sta. #	Offset in	Offset off	Elevation shot	Elevation rec	RECEIVER Station # #1	RECEIVER Station # #24	COMMENTS	PS
3E	160		4'			161.5	148.5	in a 2' ditch	
4E	161		3'			"	"		
	END OF LINE 4								
	START LINE 5 W → E								
LINE 5 STN 112.5 ⊥ LINE 4 STN 157.25									
	STN 112 is 3' E of gate post (sw entrance)								
5E	100	—	4'			135	—	Hammer	
6E	101		"			"	"	" Count [illegible]	
7E	102	—	"					" [illegible] 100-104	
8E	103	—	"			"	"	"	
9E	104	—				"	"	[illegible]	4
10E	105	—	—			"	"		5
11E	106	—	.			"	"		6
12E	107	—	—			"	"		7
13E	108	—	—			"	.		8
14E	109	—	.			"	"		
15E	110	—						LINE 1 STN 106.50 ⊥ LINE 5 STN 130	
16E	111	—	—			"			
17E	112	—	.			135.5	112.5	Fence at stn 131	
18E	113	—				"	"	Hammer	
19E	114					"	"		
20E	115	—	—				"		
21E	116	.	.			"	"		
22E	117	—				"			

SEISMIC_FIELD_NOTES

PROJECT: [illegible]	LOCATION: [illegible]	CLIENT: SAIC	
LINE: 5	DIRECTION: W → E	DATE: 12/02/87	OPERATOR: TRAFEN [illegible]
Sta. Spacing: 10'	Source Type: Hammer/Gun		[illegible] 509

REC #	SHOT Sta. #	Offset in	Offset off	Elevation shot	Elevation rec	RECEIVER Station # #1	RECEIVER Station # #24	COMMENTS	PS
23E	118	–	–			130	112.5	Hammer	
24E	119	–	–			"	"		
25E	120	–	–			"	"		
26E	121					"	"		
27E	122	–	–			"	"		
28E	123	–	–			"	"		
29E	124	–	–			147.5	124.5		0
30E	125	–	–			"	"		1
31E	126	–	–			"	"		2
32E	127	–	–						3
33E	128	–	–			"	"		4
34E	129		–			"	"		5
35E	130	–	–					Gun	6
36E	131	–	–						7
37E	132	–	–						
38E	133	–	–						
39E	134		–						
40E	135		–						
41E	136					15[illegible]	[illegible]		
42E	137								
43E	138								
44E	139								
45E	140								
[illegible]	141								

APPENDIX C:

Data Diskettes

Enclosed with the first copy of this report are a number of double-sided, high-density floppy diskettes. These contain the raw field data downloaded directly from the Bison GeoPro 8024, as well as the final processed data files and processing batch files.

These diskettes are valuable! They represent the output of a great deal of effort both acquiring and processing the data. Should this report or any of the displays be lost, they can be reproduced easily from the enclosed diskettes. Without the diskettes, the only alternative is to repeat the entire process.

MGA maintains a file of all field data, and can most likely reproduce these data even in the absence of the enclosed diskettes. However, we cannot assume responsibility for the safety of these data. It is in the client's interest to treat the enclosed diskettes carefully.

INTER-OFFICE MEMO

SAIC® Science Applications International Corporation

DATE: 11/6/89

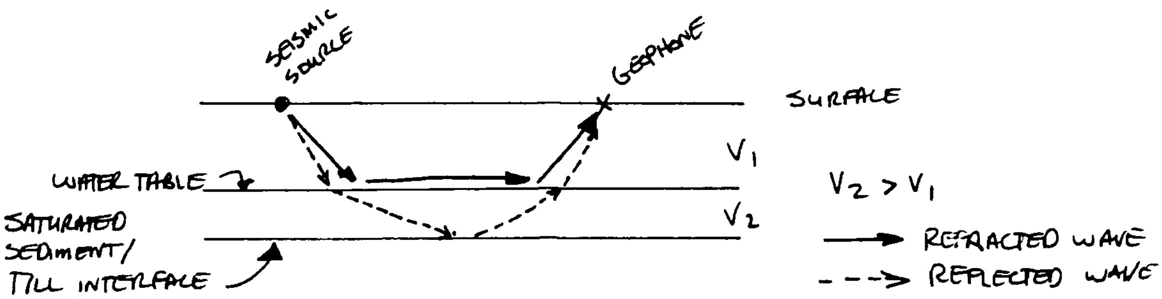
TO: ERIC GIBSON **FROM:** BRIAN DAMIATA

SUBJECT: RE-INTERPRETATION OF MGA'S SEISMIC REFLECTION SURVEY AT JOE FOSS FIELD

SUMMARIZED BELOW IS THE PERTINENT INFORMATION CONCERNING THE RE-INTERPRETATION OF SEISMIC REFLECTION DATA COLLECTED AT JOE FOSS FIELD BY MGA. THE COMMENTS ARE BASED ON CORRESPONDENCE AND PHONE CONVERSATIONS WITH PHIL DAVIS OF MGA. PHIL'S COMMENTS (SEE ATTACHED) WERE BASED ON A RE-EXAMINATION OF SEVERAL SEISMOGRAMS USING THE LITHOLOGIC LOGS AS A CONSTRAINT.

1) THE INTERPRETATION OF A BURIED CHANNEL IS OBVIOUSLY INCORRECT. IN ACTUALITY, NO DELINEATIONS CAN BE MADE BETWEEN THE SATURATED SEDIMENTS AND GLACIAL TILL INTERFACES. THE REASON FOR THIS IS DUE TO SEVERAL FACTORS. FIRSTLY, THE ACOUSTIC IMPEDANCES ARE NOT SIGNIFICANTLY DIFFERENT BETWEEN THE TWO MATERIALS (A CONCERN I HAD RAISED IN MEMO DATED 2/4/89, COMMENT #7) AND THUS, ANY REFLECTION FROM THIS INTERFACE WOULD NOT BE STRONG. SECONDLY, RESOLUTION BETWEEN SEISMIC INTERFACES IS AT BEST A MINIMUM OF ABOUT 20 FEET. FOR INTERFACES DEFINED BY HIGHLY CONTRASTING IMPEDANCES, THE RESOLUTION IS WORSE. FOR EXAMPLE, A SIGNIFICANT ACOUSTIC IMPEDANCE CHANGE OCCURS AT THE WATER TABLE (UNSATURATED/SATURATED INTERFACE) WHICH PRECLUDES THE DETERMINATION OF <u>ANY</u> STRATIGRAPHY TO A DEPTH OF 20 TO 40 FEET. THIS LACK OF RESOLUTION IS ATTRIBUTED TO THE NEAR

SIMULTANEOUS ARRIVAL OF REFRACTIONS FROM THE WATER-TABLE INTERFACE WITH REFLECTIONS FROM INTERFACES IMMEDIATELY BELOW THE WATER TABLE.



2) THE ORIGINAL INTERPRETATION OF DEPTH TO BEDROCK IS BELIEVED TO BE CORRECT. PHIL BELIEVES THE GENERAL CONFIGURATION OF THE BEDROCK SURFACE IS SLOPING TO THE WEST - NORTHWEST. ONE EXPECTS AN APPRECIABLE DIFFERENCE IN ACOUSTIC IMPEDANCES BETWEEN SATURATED SEDIMENTS - GLACIAL TILL / QUARTZITE. ONLY IF THE BEDROCK IS NOT QUARTZITE OR IF IT IS HIGHLY WEATHERED WOULD THEIR INTERPRETATION BE WRONG. NOTE THAT DEPTHS TO BEDROCK AS GIVEN IN FIGURE 1 OF MGA'S REPORT ARE CONSIDERED MINIMUM DEPTHS AS DEDUCED FROM SEISMIC REFRACTION INTERPRETATION (i.e., MINIMUM DEPTH CALCULATIONS BASED ON THE <u>LACK</u> OF HIGH VELOCITY ARRIVALS ON TIME-DISTANCE PLOTS). ACTUAL DEPTH TO BEDROCK COULD EASILY VARY 10'S OF FEET FROM THEIR INTERPRETATION. FOR EXAMPLE, IF THEIR ASSUMED VELOCITY STRUCTURE FOR THE SECOND LAYER IS INCREASED FROM 5000-6000 FT/SEC, THEN DEPTH TO BEDROCK WOULD INCREASE BY OVER 30 FEET (SEE MEMO DATED 2/14/89, COMMENT # 5). CONVERSLY, IF A SIGNIFICANT ZONE OF WEATHERED QUARTZITE IS PRESENT THEN DEPTH TO BEDROCK WOULD BE SHALLOWER THAN THEIR INTERPRETED "MINIMUM DEPTH".

3) • THE MORAL OF THIS STORY IS THAT SHALLOW SEISMIC SURVEYS CAN DEDUCE, AT BEST, ACOUSTIC INTERFACES THAT ARE NO CLOSER THAN ABOUT 20 FEET. THE GREATER THE ACOUSTIC IMPEDANCE CONTRAST BETWEEN LAYERS, THE EASIER IT IS TO DETERMINE REFLECTORS ON SEISMOGRAMS (e.g. BEDROCK REFLECTORS/REFRACTORS ARE EASIER TO DISTINGUISH THAN STRATIGRAPHIC LAYERING).

• IF ONE IS CONCERNED WITH HIGH RESOLUTION AT SHALLOW DEPTHS (SAY UPPER 20') THEN GROUND PENETRATING RADAR IS PREFERABLE TO REFLECTION. GPR USES A HIGHER FREQUENCY ENERGY SOURCE AND IS THUS ABLE TO RESOLVE MORE. HOWEVER, THE HIGHER FREQUENCIES ATTENUATE MUCH MORE RAPIDLY SO THAT DEPTH OF PENETRATION IS LIMITED.

• IDEALLY, SEISMIC REFLECTION INTERPRETATIONS ARE CONSTRAINED BY AVAILABLE LITHOLOGIC LOGS. WHEN SUCH LOGS AREN'T AVAILABLE, INTERPRETATIONS SHOULD BE REGARDED WITH EXTREME CAUTION. THE CONSTRAINT GIVEN BY A LITHOLOGIC LOG ALLOWS ONE TO EXTRAPOLATE "POINT-WISE" GEOLOGIC INFORMATION TO 2- AND 3-DIMENSIONS VIA SEISMIC INTERPRETATION. A MUCH LOWER CONFIDENCE IS PLACED ON SEISMIC INTERPRETATIONS WHICH ARE NOT CONSTRAINED.

MINNESOTA GEOPHYSICAL ASSOCIATES

November 2, 1989

Mr. Brian Damiata
SAIC
14062 Denver West Parkway
Golden, CO 80401

Dear Brian:

I had a chance to look over the information you sent for the Sioux Falls site. After reviewing the field data files, it is clear that the reflection at the top of the till layer cannot be resolved from the wave refracted along the water table. Enclosed is a copy of a field record from line 2, which highlights the resolution problem. The record is from the northeast end of the line, which is not near the wells in question, but is cleaner due to a more homogeneous near-surface.

The water table refraction intercept time is about 19 milliseconds. There appears to be a reflection, perhaps the till layer, approaching the refraction asymptotically from a zero-offset time of about 28 milliseconds. As you can see, the near offsets are obscured by ground roll (muted out during processing). Beyond the ground roll, the reflection is already within about 3 or 4 milliseconds of the refraction. Since the refraction asymptote controls the moveout of the reflection at greater offsets, the reflection cannot be corrected to an accurate zero-offset time unless it is separated from the refraction by at least 10 milliseconds or so at these offsets.

Ground roll is, at present, impossible to eliminate from shallow reflection data. The filtering achieved by geophone groups used in the oil industry doesn't work in the near-surface regime due to the non-vertical incidence of waves reflected from shallow interfaces. Until this and a few other problems can be dealt with, shallow seismic reflection seems to be limited in resolution to a minimum of 20 feet or so between interfaces, and more when close to a boundary between highly-contrasting velocities (e.g. unsaturated to saturated).

Seismic refraction can sometimes bridge the gap in the near surface. Unfortunately, the till doesn't seem to have a significantly higher velocity than the saturated sand above it, given the lack of a faster refraction on the field records.

Please let me know if I can answer any further questions. I hope this situation hasn't caused you undue inconvenience.

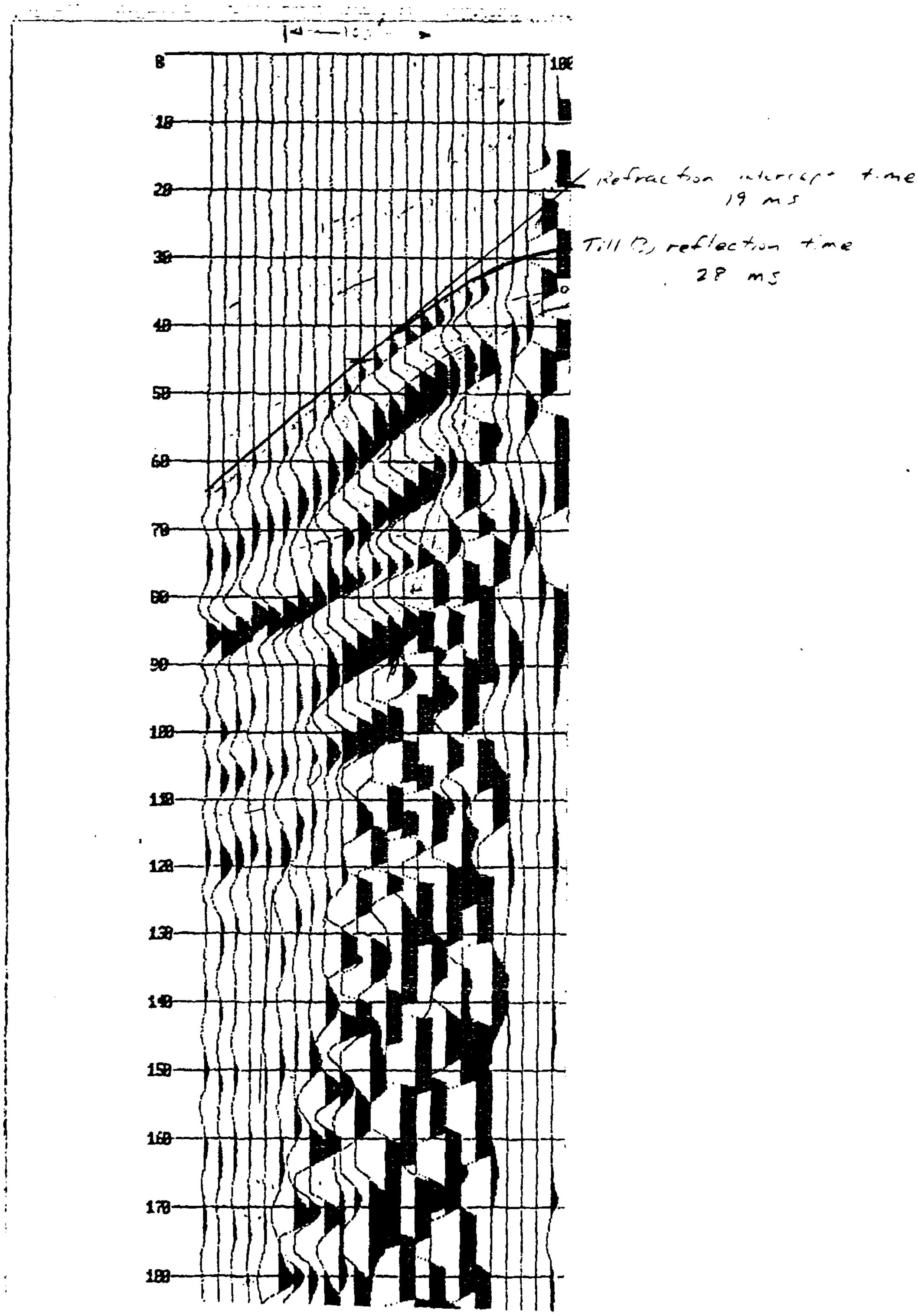
Regards,

Phil Davis

Philip A. Davis

8616 Xylon Ave. No. Suite G • Brooklyn Park, MN 55445 • (612) 493-3595 Fax 493-3597

LINE 2
STATION 100
(NE END)



APPENDIX C:

SOIL GAS/GROUNDWATER PROBE SURVEY, ON-SITE GAS CHROMATOGRAPHY RESULTS

C/934P/Disk #1 – 6/6/90

NOTICE

This report is a duplicate of a report provided to Science Applications Iternational Corporation (SAIC) by Tracer Research Corporation. Any mention of 'Joe Ross Field' is a typographical error and should be considered to be 'Joe Foss Field'.

11b	110		"			"	"	
12b	"		"			"	"	

Tracer Research Corporation

3855 North Business Center Drive • Tucson, Arizona 85705 • (602) 888-9400

ON-SITE SAMPLE ANALYSES
JOE ROSS FIELD
SIOUX FALLS, SOUTH DAKOTA

MAY 1989

PREPARED FOR:

SAIC
8400 Westpark Drive
McLean, Virginia 22102

SUBMITTED BY:

Tracer Research Corporation

TABLE OF CONTENTS

INTRODUCTION

Tracer Research Corporation (TRC) provided on-site analytical services in support of SAIC's Prime Contract with Martin Marietta at the Joe Ross Field, Sioux Falls, South Dakota. Services were performed on April 11 through May 2, 1989 under contract to SAIC. On-site GC services were provided for the analyses of soil gas and various environmental samples including soil and groundwater. Samples were collected from the Underground Fuel Storage Area, Base Fire Training Area, and various other areas.

A total of 107 soil samples, 8 groundwater samples and 5 soil gas samples were collected by SAIC and analyzed in the field by TRC. Samples were analyzed for the following compounds:

1,1,1-trichloroethane (TCA)
carbon tetrachloride (CCL4)
trichloroethene (TCE)
tetrachloroethene (PCE)
benzene
toluene
xylenes
total hydrocarbons

The compounds in this suite were chosen because of their suspected presence in the subsurface based on SAIC's findings. Xylenes are reported as the total of three isomers and total hydrocarbons are approximately C4-C9 aliphatic, alicyclic and aromatic hydrocarbons.

ANALYTICAL PROCEDURES

To perform on-site analytical work, Tracer Research Corporation (TRC) set-up a remote laboratory at Joe Ross Field, Sioux Falls, South Dakota. The lab was equipped with a Varian 3300 gas chromatograph and two Spectra Physics SP4270 computing integrators. Analytical equipment was set-up to perform groundwater and soil headspace analysis on samples collected in conjunction with a drill-rig operation. Direct injection techniques were also used for groundwater analyses. Electrical power from the facility was provided (110 volts AC) to operate all of the gas chromatographic instruments and field equipment.

A Varian 3300 gas chromatograph, equipped with a flame ionization detector (FID) and an electron capture detector (ECD), was used for the compound analyses. The ECD was used for the analyses of TCA, CCL4, TCE and PCE while the FID was used to analyze for benzene, toluene, xylenes and total hydrocarbons. Separation of these compounds was achieved by running the samples on 1/8 inch OD packed columns with OV-101 as the stationary phase. Nitrogen was used as the carrier gas.

Halocarbon and hydrocarbon compounds detected in samples are identified by chromatographic retention time. Quantification of compounds is achieved by comparison of the detector response of the sample with the response measured for calibration standards (external standardization). Instrument calibration checks are run periodically throughout the day as are syringe blanks to check for contamination in the headspace sampling equipment.

Soil samples were collected by split-spoon or a similar method and immediately prepared for analysis by TRC in the remote laboratory. Approximately 10 grams of soil and 10 mL of water was placed in a 40 mL teflon sealed VOA bottle leaving approximately 20 mL of headspace. Each VOA was then shaken vigorously for 30

seconds before the headspace was analyzed. This allows for the desorption of volatile compounds from the soil into the water and then the partitioning of these compounds into the headspace of the vial. Headspace vapor is subsampled (duplicate injections) in volumes ranging from 1 uL to 2 mL.

The GC was calibrated for headspace analysis by decanting 10 to 20 mL off of the known aqueous standard so as to leave approximately the same amount of headspace that was in the soil headspace samples. The bottle was then resealed and shaken vigorously for 30 seconds. An analysis of the headspace in the vial determines the Response Factor (RF) which is then used to accurately estimate soil concentrations. The headspace analysis technique allows for larger injection volumes.

Detection limits are a function of the injection volume as well as the detector sensitivity for individual compounds. Thus, the detection limit varies with the sample size. Generally, the larger the injection size the greater the sensitivity. However, peaks for compounds of interest must be kept within the linear range of the detector. If any compound has a high concentration, it is necessary to use small injections, and in some cases to dilute the sample to keep it within linear range. This may cause decreased detection limits for other compounds in the analyses. The detection limits range down to 0.003 ug/kg for halocarbon compounds and 1 ug/kg for hydrocarbon compounds depending on the conditions of the measurement, in particular, the sample size. If any component being analyzed is not detected, the detection limit for that compound in that analysis is given as a "less than" value (e.g. <0.003 ug/kg). This number is calculated from the current response factor, the sample size, and the estimated minimum peak size (area) that would have been visible under the conditions of the measurement.

QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

Tracer Research Corporation's normal quality assurance procedures were followed in order to prevent any cross-contamination of soil samples.

- Glass syringes are used for only one sample per day and are washed and baked out at night.
- Septa through which soil gas samples are injected into the chromatograph are replaced on a daily basis to prevent possible gas leaks from the chromatographic column.
- Analytical instruments are calibrated each day by the use of chemical standards prepared in water by serial dilution from commercially available pure chemicals. Calibration checks are also run after approximately every five soil sampling locations.
- 2 cc subsampling syringes are checked for contamination prior to sampling each day by injecting nitrogen carrier gas into the gas chromatograph.
- All sampling and 2 cc subsampling syringes are decontaminated each day and no such equipment is reused before being decontaminated. Microliter size subsampling syringes are reused only after a nitrogen carrier gas blank is run to insure it is not contaminated by the previous sample.

ONSITE GAS CHROMATOGRAPH DATA SUMMARY

TABLE C-1. SUMMARY OF TOTAL VOLATILE HYDROCARBONS FROM SOIL HEADSPACE ANALYSIS AT SOUTH DAKOTA AIR NATIONAL GUARD, JOE FOSS FIELD, SIOUX FALLS, SOUTH DAKOTA

SAMPLE	DATE	TOTAL VOLATILE HYDROCARBON*	SAMPLE	DATE	TOTAL VOLATILE HYDROCARBON*
B1-1-5	04/11/89	70	B3-2-0	04/14/89	ND
B1-1-10	04/11/89	17000	B3-2-2.5	04/14/89	ND
B1-1-15	04/11/89	56000	B3-2-5	04/14/89	ND
B1-1-20	04/11/89	18000	B3-2-7.5	04/14/89	ND
B1-1-20R2	04/11/89	52000	B3-2-10	04/14/89	ND
B1-1-25	04/11/89	36000	B3-3-0	04/14/89	100000
DRILL H20	04/11/89	ND	B3-3-2.5	04/14/89	86000
B1-1-30	04/12/89	30000	B3-3-5	04/14/89	5200
B1-1-35	04/12/89	570	B3-3-7.5	04/14/89	9400
B1-1-40	04/12/89	170	B3-3-10	04/15/89	38000
B1-1-45	04/12/89	360	B3-3-12.5	04/14/89	ND
B1-1-50	04/12/89	220	B3-3-15	04/14/89	ND
B1-2-5	04/13/89	ND	B3-3-17.5	04/14/89	ND
B1-2-10	04/13/89	ND	B3-4-0	04/15/89	ND
B1-2-15	04/13/89	200000	B3-4-5	04/15/89	ND
B1-2-20	04/13/89	110	B3-4-7.5	04/15/89	ND
B1-2-25	04/13/89	120000	B3-4-10	04/15/89	ND
B1-2-30	04/13/89	8800	B3-5-0	04/15/89	ND
B1-2-35	04/13/89	830	B3-5-2.5	04/15/89	ND
B1-2-40	04/13/89	ND	B3-5-5	04/15/89	6
MW1-5-5	04/16/89	ND	MW3-5-5	04/15/89	ND
MW1-5-10	04/16/89	ND	MW3-5-10	04/15/89	ND
MW1-5-15	04/16/89	190	MW3-5-15	04/15/89	ND
MW1-5-20	04/16/89	79	MW3-5-25	04/15/89	ND
MW1-5-25	04/16/89	84	BK-2-5	04/29/89	ND
MW1-5-30	04/16/89	36	BK-2-10	04/29/89	ND
MW1-6-5	04/16/89	ND	BK-2-15	04/29/89	ND
MW1-6-10	04/16/89	ND	BK-2-20	04/29/89	ND
MW1-6-15	04/16/89	0.8	BK-2-25	04/29/89	ND
MW1-6-20	04/16/89	140	BK-3-0.5	04/29/89	ND
MW1-6-25	04/16/89	ND	BK-3-5	04/29/89	ND
MW1-6-30	04/16/89	ND	BK-3-20	04/29/89	ND
MW1-7-5	04/17/89	ND	GP1-100	04/18/89	ND
MW1-7-10	04/17/89	ND	GP1-101	04/18/89	ND
MW1-7-15	04/17/89	ND	GP1-102	04/18/89	190
MW1-7-20	04/17/89	ND	GP1-103	04/18/89	3100
MW1-8-5	04/17/89	ND	GP1-104	04/18/89	1900
MW1-8-10	04/17/89	2500	GP1-105	04/18/89	110
MW1-8-15	04/17/89	38000	GP1-106	04/24/89	31
MW1-8-20	04/17/89	18000	GP1-107	04/24/89	ND
MW1-8-25	04/17/89	660	GP1-108	04/24/89	200000
MW1-8-30	04/17/89	ND	GP1-109	04/18/89	43
MW1-9-5	04/25/89	ND	GP1-110	04/18/89	ND
MW1-9-10	04/25/89	ND	GP1-111	04/18/89	ND
MW1-9-15	04/25/89	ND	GP1-112	04/18/89	ND
MW1-9-20	04/25/89	ND	GP1-113	04/18/89	ND
MW1-9-25	04/25/89	ND	GP1-114	04/18/89	ND
MW1-10-5	04/26/89	ND	GP1-115	04/19/89	32
MW1-10-10	04/26/89	ND	GP1-116	04/19/89	ND
MW1-10-15	04/26/89	ND	GP1-117	04/19/89	6
MW1-10-20	04/26/89	ND	GP1-118	04/19/89	ND
MW1-10-25	04/26/89	ND	GP1-119	04/19/89	ND
MW1-11-5	04/26/89	ND	GP1-120	04/24/89	ND
MW1-11-10	04/26/89	ND	GP1-121	04/24/89	ND
MW1-11-15	04/26/89	ND	GP1-122	04/24/89	230
MW1-11-20	04/26/89	ND	GP1-123	04/24/89	ND
MW1-11-25	04/26/89	ND	GP1-124	04/24/89	76
MW1-12-5	04/27/89	ND	GP1-125	04/25/89	ND
MW1-12-10	04/27/89	ND	GP1-126	04/25/89	ND
MW1-12-15	04/27/89	240000	GP1-127	04/25/89	10000
MW1-12-20	04/27/89	2400	GP1-128	04/25/89	230
MW1-12-25	04/27/89	640	GP1-129	04/25/89	7400
MW1-12-30	04/27/89	ND	GP1-130	04/25/89	530
MW1-13-5	04/27/89	ND	GP1-131	04/25/89	ND
MW1-13-10	04/27/89	ND	GP1-132	04/25/89	ND
MW1-13-15	04/27/89	ND	GP1-133	04/25/89	ND
MW1-13-20	04/27/89	ND	GP1-134	04/25/89	ND
MW1-13-25	04/27/89	ND	SG3-1-4	04/13/89	ND
MW1-14-5	04/28/89	ND	SG3-2-4	04/13/89	ND
MW1-14-10	04/28/89	ND	SG3-3-3	04/13/89	ND
MW1-14-15	04/28/89	ND	SG3-4-4	04/13/89	ND
MW1-14-20	04/28/89	ND	SG3-5-2	04/13/89	ND
MW1-14-25	04/28/89	ND	SG3-6-4	04/14/89	2
B3-1-5	04/14/89	11000	SG3-7-4	04/14/89	ND
B3-1-7.5	04/14/89	9200	SG3-8-4	04/14/89	ND
B3-1-10	04/14/89	ND	SG3-9-4	04/14/89	ND
B3-1-15	04/14/89	ND	SG3-10-4	04/14/89	ND

ND - Indicates no analytes were detected. * - Units are PPB.

APPENDIX D:

GEOTECHNICAL ANALYSES RESULTS

Chen-Northern, Inc.

96 South Zuni
Denver, Colorado 80223
303/744-7105
FAX: 303/744-0210

Billings
Boise
Casper
Colorado Springs
Denver
Elko
Evanston
Gillette
Glenwood Springs
Great Falls
Helena
Phoenix
Pocatello
Rock Springs
Salt Lake City
San Antonio
Tri Cities
Yakima

June 29, 1989

Subject: Laboratory Testing, Joe Foss field,
Subcontract No. 16-890009-82, SAIC
Subproject No. 1-827-33-769-05

Job No. 1 555 89

Ms. Connie Samson
SAIC
8400 Westpark Drive
McLean, Virginia 22102

Dear Ms. Samson:

As requested, we have performed laboratory testing on soil samples received April 20, and May 9, 1989 at our Denver laboratory. Testing consisted of moisture-densities, hydrometer analyses, Atterberg limits testing, cation exchange capacity, and organic matter content. Testing was performed in general accordance with ASTM and EPA test procedures as specified in the contract scope of work.

Test results are shown on Figs. 1 through 4 and on the attached Summary of Laboratory Test Results, Table I. Copies of laboratory work sheets are enclosed.

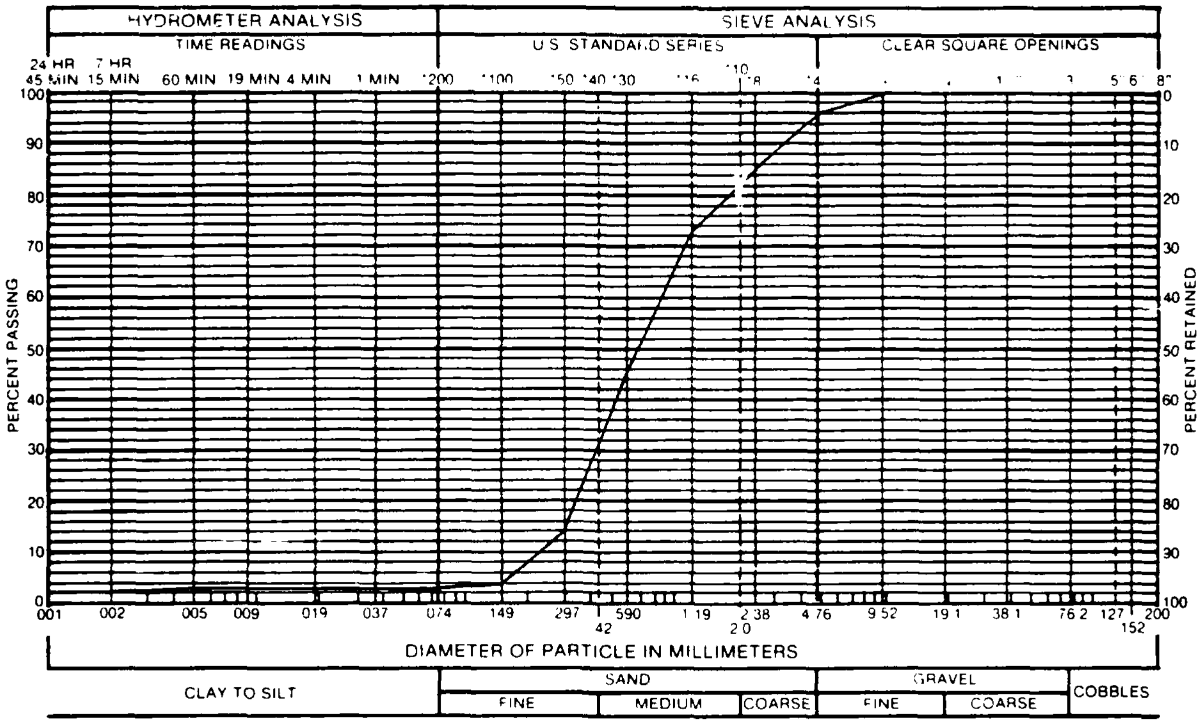
If you have any questions or if we can be of further service, please call.

Sincerely,

CHEN-NORTHERN, INC.

By Norman F. Lewis
Norman F. Lewis
Laboratory Manager

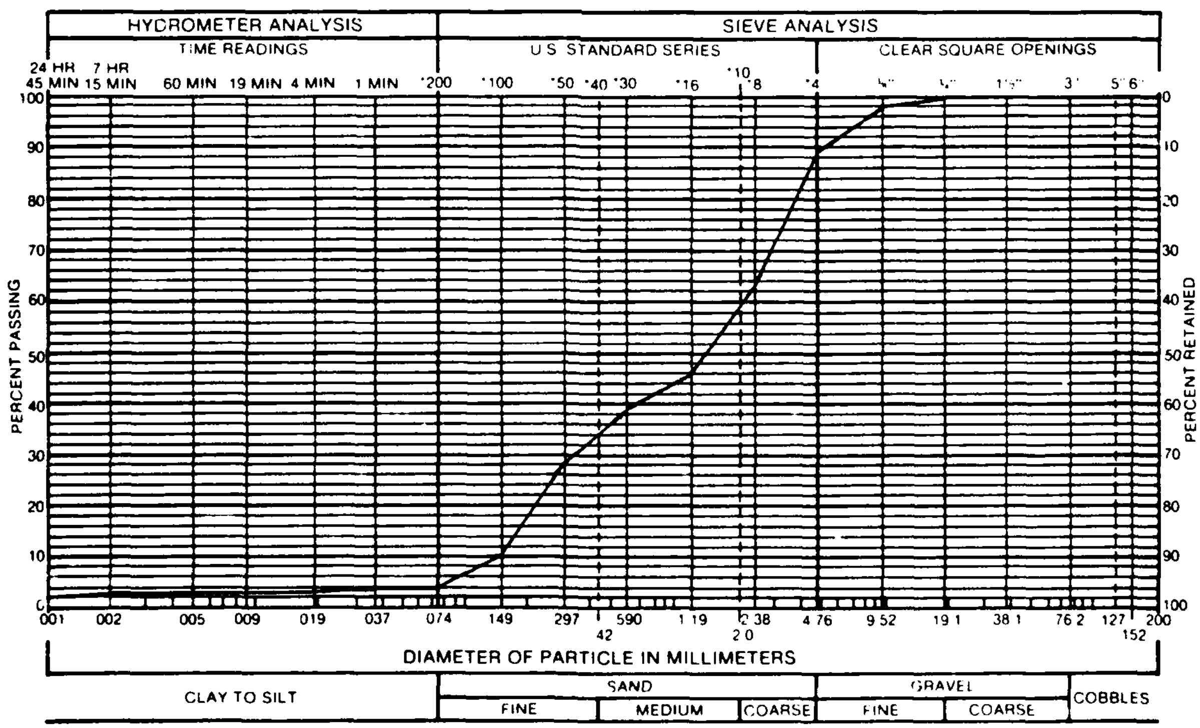
NFL/mq
Rev. By: AJG
Enclosures



GRAVEL 4 % SAND 93 % SILT AND CLAY 3 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF FROM MW 1 14GT at depth 12-14'



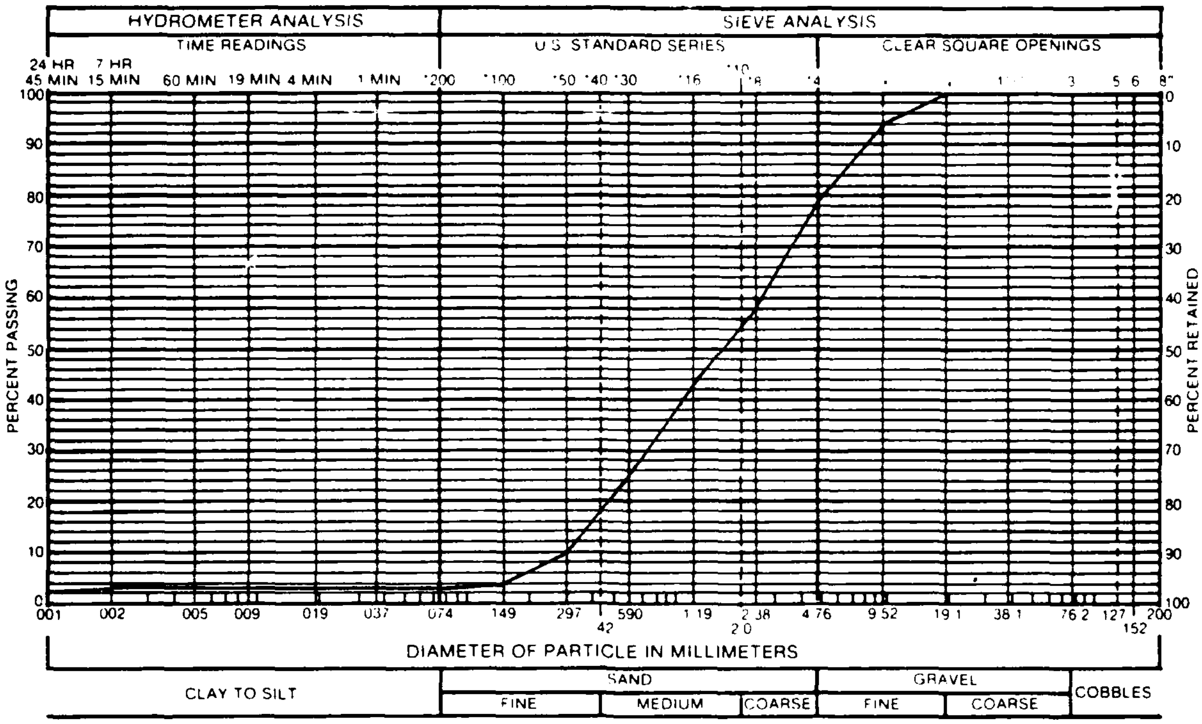
GRAVEL 11 % SAND 85 % SILT AND CLAY 4 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF FROM MW 1 14GT at depth 17-19'

1 555 89	***Chen-Northern, Inc.***	GRADATION TEST RESULTS	**Fig.** 1

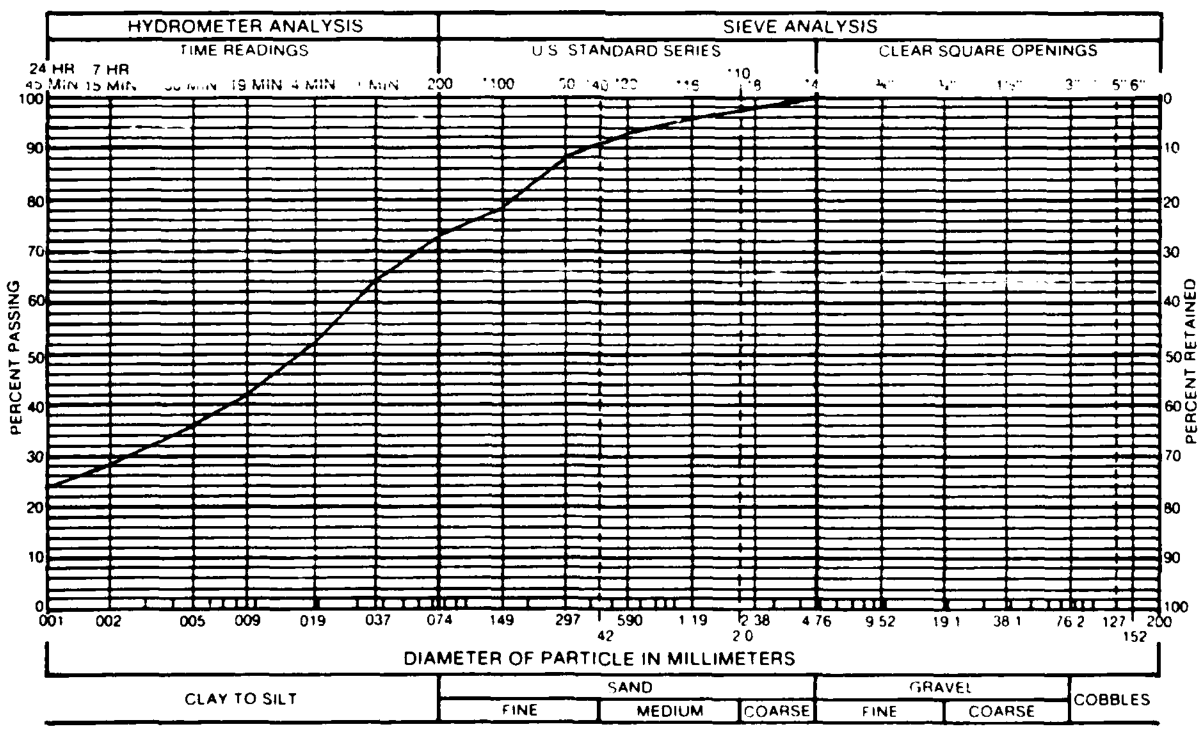
CA-2-79



GRAVEL 21 % SAND 76 % SILT AND CLAY 3 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF FROM MW 1-9 at depth 12-14'



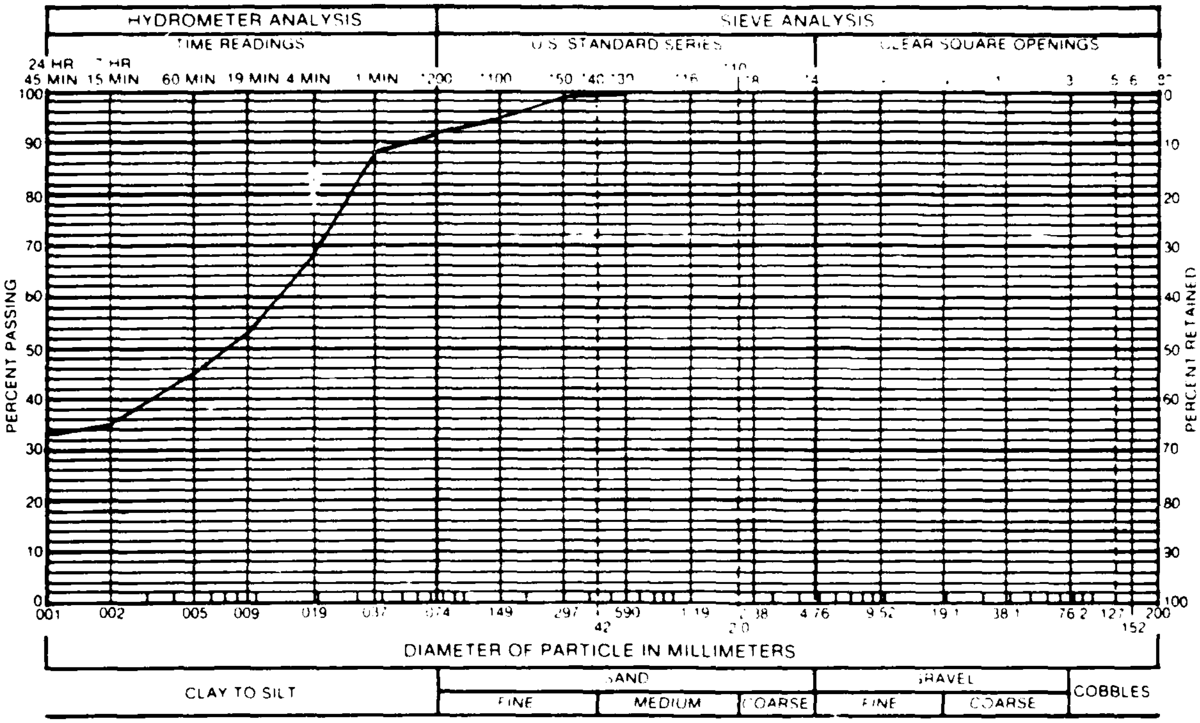
GRAVEL % SAND 27 % SILT AND CLAY 73 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF FROM B 1-2 at depth 42-44'

1 555 89	***Chen-Northern, Inc.***	GRADATION TEST RESULTS	**Fig.** 2

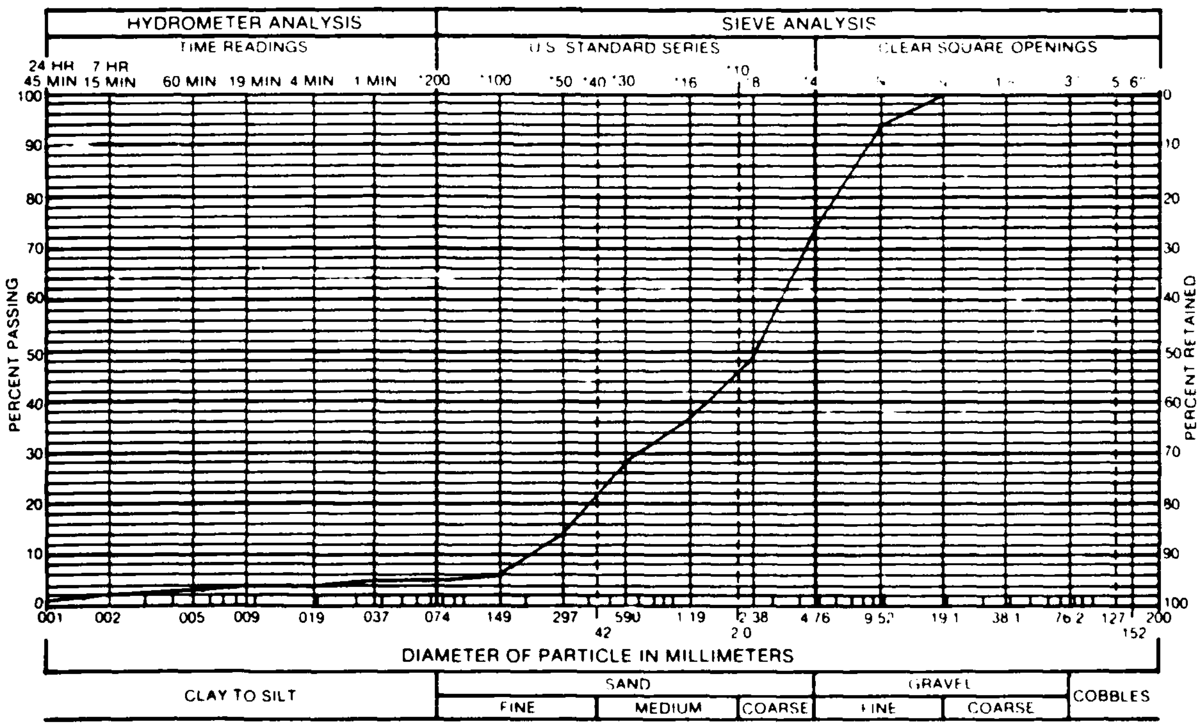
CA-2-79



GRAVEL % SAND 8 % SILT AND CLAY 92 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF FROM B 3-1 at dpeth 2-4'



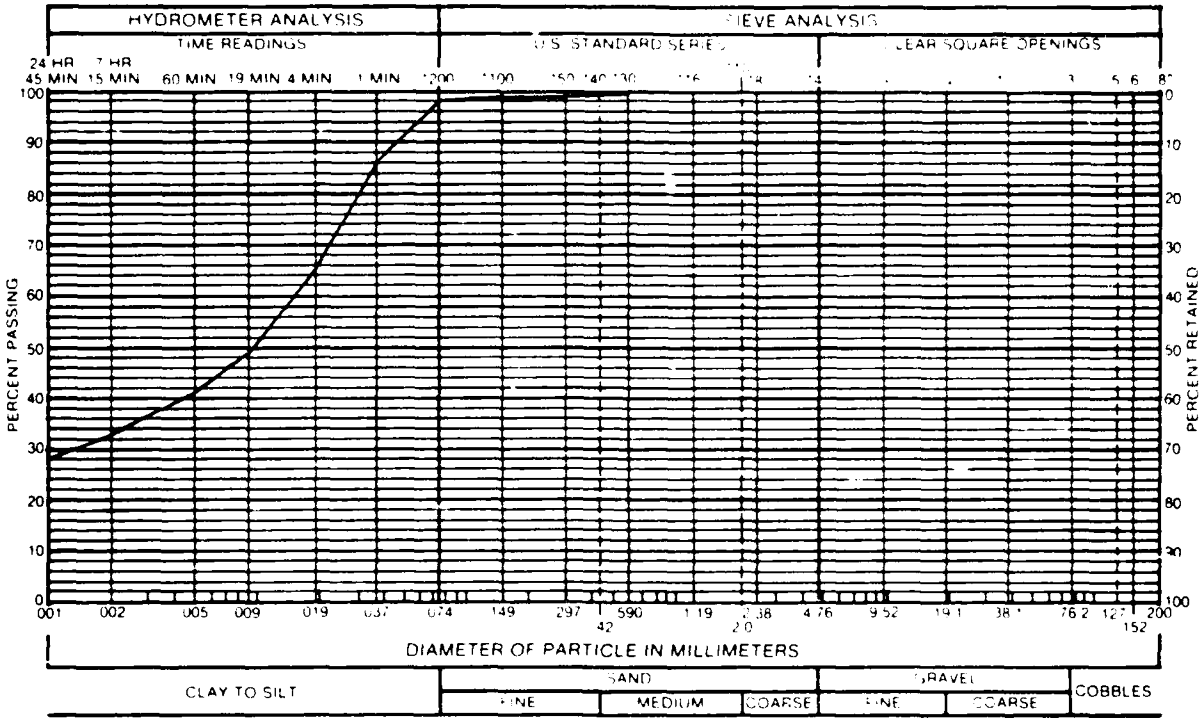
GRAVEL 26 % SAND 70 % SILT AND CLAY 4 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF FROM B 3-1 at depth 12-14

1 555 89	*Chen-Northern, Inc.*	GRADATION TEST RESULTS	Fig 3

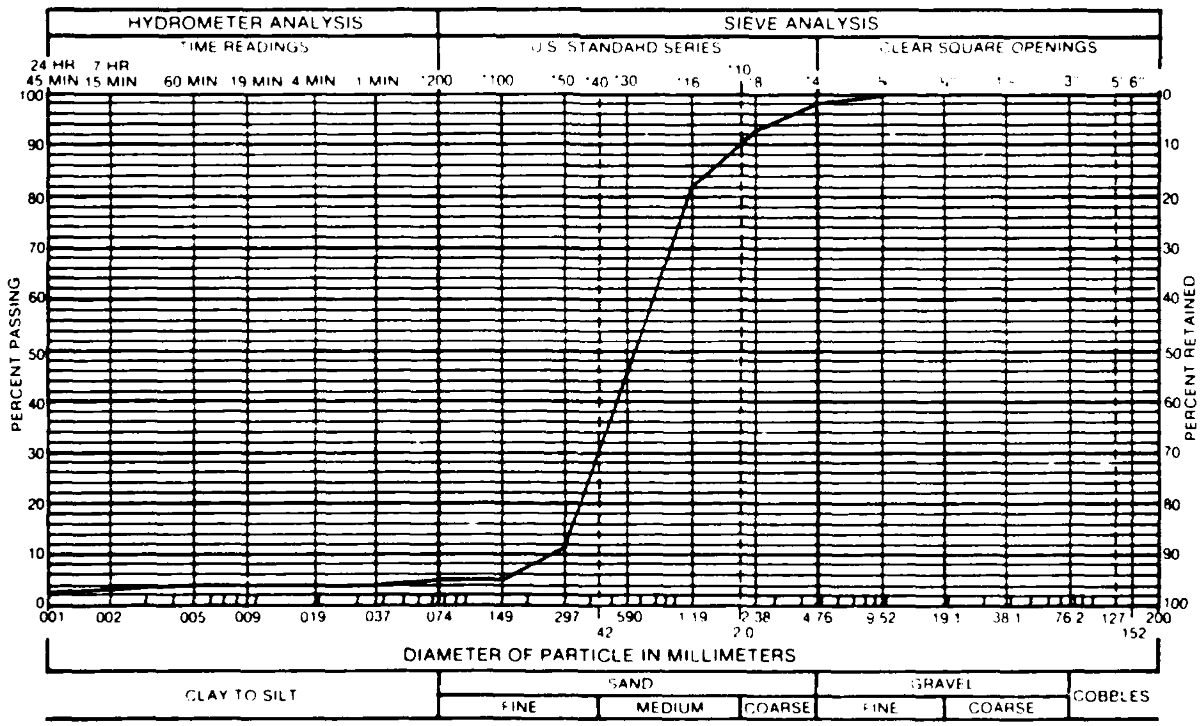
CA-2-79



GRAVEL % SAND 2 % SILT AND CLAY 98 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF FROM B 3-5 at depth 2-4



GRAVEL 2 % SAND 93 % SILT AND CLAY 5 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF FROM B 3-5 at depth 12-14

1 555 89	*Chen-Northern, Inc.*	GRADATION TEST RESULTS	Fig. 4

CA-2-79

Chen-Northern, Inc.

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

Job No. 1 555 89

SAMPLE LOCATION		NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	GRADATION		PERCENT PASSING NO 200 SIEVE	ATTERBERG LIMITS		CAT-ION EXCHANGE CAPACITY MEG/100gm	ORGANIC CONTENT (%)	SOIL OR BEDROCK TYPE
HOLE	DEPTH (feet)			GRAVEL (%)	SAND (%)		LIQUID LIMIT (%)	PLASTICITY INDEX (%)			
MW1 14GT	12-14	12.8		4	93	3	NON-P	LASTIC		.74	Sand (SP)
MW1 14GT	17-19	12.6		11	85	4	NON-P	LASTIC		.67	Gravelly sand (SP)
MW1-9	12-14	3.8	122.9	21	76	3	NON-P	LASTIC		.21	Gravelly sand (SW)
B1-2	42-44	16.0	115.5		27	73	33	19		1.32	Sandy clay (CL)
B3-1	2-4	29.1	89.1		8	92	49	25		2.63	Slightly sandy clay (CL)
B3-1	12-14	3.5	138.6	26	70	4	NON-P	LASTIC		.16	Gravelly sand (SP)
B3-5	2-4	20.4	88.5		2	98	51	28		3.54	Clay (CH)
B3-5	12-14	2.7	107.9	2	93	5	NON-P	LASTIC		.18	Sand (SP)
MW1-9-20									1.51		
MW1-10-20									1.31		
MW1-11-20									3.83		
MW1-12-20									1.27		
BK-2-15									.914		

Chen-Northern, Inc.

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

Job No. 1 555 89

SAMPLE LOCATION		NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	GRADATION		PERCENT PASSING NO 200 SIEVE	ATTERBERG LIMITS		CAT-ION EXCHANGE CAPACITY MEQ/100gm	ORGANIC CONTENT (%)	SOIL OR BEDROCK TYPE
HOLE	DEPTH (feet)			GRAVEL (%)	SAND (%)		LIQUID LIMIT (%)	PLASTICITY INDEX (%)			
BK-2-20									.957		
BK-2-25									1.09		
BK-3-5									30.3		
BK-3-5									13.0		
BK-3-20									3.37		
B1-1-15									1.9		
B1-1-25									2.4		
B1-2-15									.8		
B1-2-25									2.0		
B3-1-0									22.7		
B3-2-5									22.6		
B3-3-2.5									28.4		
B3-4-0									31.8		
B3-5-25									39.7		
MW1-5-15									1.2		

Chen-Northern, Inc.

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

Job No. 1 555 89

SAMPLE LOCATION		NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	GRADATION		PERCENT PASSING NO 200 SIEVE	ATTERBERG LIMITS		CAT-ION EXCHANGE CAPACITY MEQ/100 gm	ORGAN. CONTEN. (%)	SOIL OR BEDROCK TYPE
HOLE	DEPTH (feet)			GRAVEL (%)	SAND (%)		LIQUID LIMIT (%)	PLASTICITY INDEX (%)			
MW1-6-20									1.3		
MW1-7-15									3.0		
MW1-8-20									1.1		

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Chain of Custody Record

Date 4/18/89 Page 1 of 1

1

Name Eric Gibson
Address See below right
Phone Number On-Site (605) 333-5785
Project Manager Connie Samson
Project Name Joe Foss Field
Job/P.O. No. R 5292325 (SAIC)

Sampler (Signature) J. Eric Gibson (Printed Name) J. Eric Gibson

Laboratory Name Chen & Assoc.
Address 96 S. Zuni St.
Denver, CO 80223
Phone (303) 744-7105
Contact Name

Requested Parameters: Cation Exchange Cap.; Contaminated Samples (with fuel)

Laboratory No.	Matrix	Sample No.	Date	Time	Site/Zone	Cation Exchange Cap.	Contaminated Samples (with fuel)	No. of Containers	Observations, Comments, Special Instructions
	Soil	B1-1-15	4/11	1430	SITE 1	✓	*	1	All work as per
	Soil	B1-1-25	4/11	1740	SITE 1	✓	*	1	Statement of Work
	Soil	B1-2-15	4/12	0745	SITE 1	✓	*	1	
	Soil	B1-2-25	4/13	0930	SITE 1	✓	*	1	
	Soil	B3-1-0	4/14	1150	SITE 3	✓	*	1	
	Soil	B3-2-5	4/14	1048	SITE 3	✓	*	1	
	Soil	B3-3-2.5	4/14	1350	SITE 3	✓	*	1	
	Soil	B3-4-0	4/15	0745	SITE 3	✓		1	
	Soil	B3-5-2.5	4/15	0925	SITE 3	✓		1	
	Soil	MW-1-5-15	4/16	0945	SITE 1	✓	*	1	
	Soil	MW-1-6-20	4/16	1515	SITE 1	✓	*	1	
	Soil	MW1-7-15	4/17	0855	SITE 1	✓		1	
	Soil	MW1-8-20	4/17	1300	SITE 1	✓	*	1	

Relinquished by	Date / Time	Received by	Date / Time
Signature: J. Eric Gibson Printed Name: J. Eric Gibson Company: SAIC	Date: 4/18 Time: 1600	Signature: Printed Name: Company:	Date: Time:
Signature: Printed Name: Company:	Date: 4/20 Time: 9:15	Signature: Norman Lewis Printed Name: Norman Lewis Company: Chen-Northern	Date: Time:

Total Number of Containers: 13

Shipment Method: Fed Ex

Instructions

1. Fill out form completly except for shaded areas (lab use only).
2. Complete in ballpoint pen. Draw one line through errors and initial.
3. Request analyses using EPA method method numbers only. Consult the project QAPP for instructions. Complete as shown
4. Reference all field QC samples to the applicable site or zone.
5. Note all applicable preservatives.
6. Group all sample containers and requested analyses from one sampling location together. Do not list individually

SAIC Location (circle)

Washington, D.C. 8400 Westpark Dr., McLean, VA 22102 (703) 734 2500

Oakridge 800 Oakridge Tnpk., Oakridge, TN 37830 (615) 482 9031

Paramus One Sears Drive, Paramus, NJ 07652 (201) 599 0100

Denver 1626 Cole Boulevard, Suite 270, Golden, CO 80401 (303) 231 9094

Seattle 13400B Northup Way, S38, Bellevue, WA 98005 (206) 747 7899

San Diego 4224 Campus Point, Building 3, San Diego, CA 92121 (619) 535 7438

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Chain of Custody Record

Date 5-5-89 Page 1 of 2

Shipment No. 2

Name Eric Gibson
Address See Below Right
Phone Number (703) 827-8125
Project Manager Connie Samson
Project Name Joe Foss Field
Job/P.O. No.

Sampler (Signature) J. Eric Gibson (Printed Name) J. Eric Gibson

Laboratory Name Chen
Address 96 S. Zuni
Denver, CO 80223
Phone (303) 744-7105
Contact Name [redacted]

Laboratory No.	Matrix	Sample No.	Date	Time	Site/Zone	Requested Parameters: Cation Exchange Cap	No. of Containers	Observations, Comments, Special Instructions
	Soil	BK 2-15	4/..	1620	—	1	1	bag
	Soil	BK 2-20		1635	—	1	1	bag
	Soil	BK 2-25	4/28	1650	—	1	1	bag
	Soil	BK 3-0.5	4/28	1800	—	1	1	bag
	Soil	BK 3-5	4/28	1820	—	1	1	bag
	Soil	BK 3-20	4/28	1850	—	1	1	bag
	Soil	MW1-9-20	4/25	0910	Site 1	1	1	bag
	Soil	MW1-10-20	4/26	0936	Site 1	1	1	bag
	Soil	MW1-11-20	4/26	1525	Site 1	1	1	bag
	Soil	MW1-12-20	4/27	0950	Site 1	1	1	bag

Total Number of Containers:

Shipment Method: Fed Ex

Relinquished by	Date	Received by	Date
Signature: J. Eric Gibson	5/5	Signature	
Printed Name: J. Eric Gibson	Time: 1600	Printed Name	Time
Company: SAIC		Company	
Relinquished by	Date	Received by	Date
Signature		Signature	
Printed Name	Time	Printed Name	Time
Company		Company	

Instructions

1. Fill out form completly except for shaded areas (lab use only).
2. Complete in ballpoint pen. Draw one line through errors and initial.
3. Request analyses using EPA method method numbers only. Consult the project QAPP for instructions. Complete as shown.
4. Reference all field QC samples to the applicable site or zone.
5. Note all applicable preservatives.
6. Group all sample containers and requested analyses from one sampling location together. Do not list individually

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(615) 482-9031

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(201) 599-0100

Denver
1626 Cole Boulevard, Suite 270, Golden, CO 80401
(303) 231-9094

Seattle
13400B Northup Way, S38, Bellevue, WA 98005
(206) 747-7899

San Diego
4224 Campus Point, Building 3, San Diego, CA 92121
(619) 535-7438

Science Applications International Corporation
An Employee-Owned Company

Chain of Custody Record

Date 5-5-89 Page 2 of 2

Shipment No. 2

Name ERIC GIBSON
Address SEE BELOW RIGHT
Phone Number (703) 827-8125
Project Manager CONNIE SAMSON
Project Name JOE FOSS FIELD
Job/P.O. No.
Sampler (Signature) (Printed Name)

Laboratory Name CHEN
Address 96 S. Zuni
Denver, CO 80223
Phone (303) 744-7105
Contact Name [redacted]

Laboratory No.	Matrix	Sample No.	Date	Time	Site/Zone	Soil Eng Class.	Grain Size	Atterberg (where app)	Organic Matter Cont.	Bulk Density	% Moisture								No. of Containers	Observations, Comments, Special Instructions
	Soil	B1-2 (42-44)				✓	✓	✓	✓	✓	✓								1	See SOW for
	Soil	MW1-14GT (12-14)				✓	✓	✓	✓	–	✓								2	Details
	Soil	MW1-14GT (17-19)				✓	✓	✓	✓	–	✓								2	
	Soil	MW1-9GT (12-14)				✓	✓	✓	✓	✓	✓								1	
	Soil	B3-1 (2-4)				✓	✓	✓	✓	✓	✓								1	
	Soil	B3-1 (12-14)				✓	✓	✓	✓	✓	✓								1	
	Soil	B3-5 (2-4)				✓	✓	✓	✓	✓	✓								1	
	Soil	B3-5 (12-14)				✓	✓	✓	✓	✓	✓								1	

Relinquished by	Date	Received by	Date
Signature: J. Eric Gibson	5/5	Signature	
Printed Name: J. ERIC GIBSON	Time 1600	Printed Name	Time
Company: SAIC		Company	
Relinquished by	Date	Received by	Date
Signature		Signature	
Printed Name	Time	Printed Name	Time
Company		Company	

Total Number of Containers: 20

Shipment Method: FED EX

Instructions

1. Fill out form completly except for shaded areas (lab use only).
2. Complete in ballpoint pen. Draw one line through errors and initial.
3. Request analyses using EPA method method numbers only. Consult the project QAPP for instructions. Complete as shown.
4. Reference all field QC samples to the applicable site or zone.
5. Note all applicable preservatives.
6. Group all sample containers and requested analyses from one sampling location together. Do not list individually

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(303) 231-9094

Seattle
13400B Northup Way, S38, Bellevue, WA 98005
(206) 747-7809

San Diego
4224 Campus Point, Building 3, San Diego, CA 92121
(619) 535-7438

SAMPLE RECEIPT RECORD

JOB NO. I-555-89 PART NO. ______

PROJECT ENGINEER/SUPERVISOR: NPL

JOB NAME: SAIC - Joe Foss Field

CONTRACT NO: ______

SITE LOCATION: ______

FOR OFFICE USE ONLY
CHECKED BY
LOGGED BY
COMPUTER CODES

DATE IN: 5/9/89 REC'D BY: MM DELIVERED BY: ______

CHECKED BY: NPL STORAGE TERM: ______ ☒ SEE ENGINEER

SITE ID	HOLE NO./ LOCATION	SAMPLE NO.	DEPTH, FT.	SAMPLE TYPE (DIAM.)	LAB NO.	SAMPLE CONDITION	INITIAL STAGING LOCATION	FINAL STORAGE LOCATION	REMARKS / NOTE CONTAMINATION
	MW1-14-GT	T	12-14	Jar		Good			
	MW1-14GT	B	12-14	Jar		Good			
	MW1-14GT	T	17-19	Jar		Good			lid loose - leaking H_2O
	MW1-14GT	B	17-19	Jar		Good			
	MW1-9-20	—	—	SD		Good			thin ziplock bags
	MW1-10-20	—	—	SD		Good			
	MW1-11-20	—	—	SD		Good			
	MW1-12-20	—	—	SD		Good			
	BK-2-15	—	—	SD		fair			bag leaking H_2O
	BK-2-20	—	—	SD		Good			thin ziplock bag
	BK-2-25	—	—	SD		Good			
	BK-3-0.5	—	—	SD		Good			
	BK-3-5	—	—	SD		Fair/Poor			Bag torn
	BK-3-20	—	—	SD		Good	rack		thin ziplock bag
	MW1-9	—	12-14'	3" ST		Good			shelby tubes packed
	B1-2	—	42-44	3" ST		Good			upside-down in
	B3-1	—	2-4'	3" ST		Good			cardboard carton
	B3-1	—	12-14'	3" ST		Good			w/ plastic peanut
	B3-5	—	2-4'	3" ST		Good			filling - box in poor
	B3-5	—	12-14'	3" ST		Good*			to fair cond. when
									received

* end of tube damaged prior to shipment

TYPE OF DISPOSAL

☐ RETURN TO CLIENT ☐ DUMPSTER AUTHORIZED BY ______ DATE ______

☐ OTHER ______ DATE DISPOSED ______ BY ______

-51-2(4/88)

JOB NO. 1500 37 PART NO. ______ chen and associates, inc. PREP. BY ______ CALC. BY UM DATE ______

JOB NAME SAIC Joe Foss Field

MOISTURE & DENSITY WORKSHEET

CKED. BY MG SHEET ___ OF ___

IDENTIFICATION				TEST RESULTS				MOISTURE DETERMINATION				DENSITY DETERMINATION				
HOLE NO.	SAMPLE NO.	DEPTH FEET	SAMPLE TYPE	% MOISTURE	DRY DENSITY PCF	UNIF. CLASS	DESCRIPTION BLOW COUNT, COMPONENTS, COLOR, MOISTURE CONSISTENCY, STRUCTURE, OTHER	DISH NO.	WT. OF WET SOIL AND DISH	WT. OF DRY SOIL AND DISH	WT. OF DISH	SAMPLE LENGTH IN.	SAMPLE DIAMETER IN.	WT. OF WET SOIL AND TARE	WT. OF TARE	WT. OF WET SOIL
NDH MGT		12-14	JAR	12.84		Sm	Sand, v.sli clayey, med brown, moist HCL-se	WIN	352.3	334.2	193.2					
MW1 14GT		17-19	JAR	12.61		S	Sand, v.sli clayey, med gray-brown, moist HCL-se	XRAY	406.6	~~382.8~~	194.0					
MW1 L-9		12-14	ST	3.84	122.86	S	Sand, clayey, med brown, mottled, lt moist HCL-se	ROBO	510.9	500.9	240.8	8.50	2.86	2442.6	633.9	1808.7
B 1-2		42-44	ST	15.95	115.40	CL	Clay, hard, sandy, med gray, moist, sm pockets HCL-e, blockey	BITE	382.6	356.8	195.0	3.56	2.879			814.7
B 3-1		2-4'	ST	2.08	89.08	CL	Clay, hard, sli sandy, dark brown lt. moist, Nonhog, HCL-e, contaminated w/ss solvents	IRA	295.1	259.8	139.4	1.67	2.870			326.1
B 3-1		12-14	ST	3.47	138.44	S	Sand, soft, v.sli clayey, lt gray-tan, lt moist, HCL-se	72	435.0	425.2	142.5	1.62	[illegible]	[illegible]	318.8	391.9
B 3-5		2-4	ST	2.38	86.54	CL	Clay, hard, sli sandy, dark brown, lt moist-moist, HCL-ne, Nonhog	AR1	313.4	282.6	131.5	2.20	2.856			394.3
B 3-5		12-14	ST	2.73	107.85	S	Sand, soft, v.sli clayey, med gray-tan, lt moist, HCL-e	UBY	554.4	546.1	241.7	19.32	2.86	5116.5	1506.9	3609.6

1-3 (5/85)

JOB NO. 1-555-89 PART NO. 2 — chen and associates, Inc. — PREP. BY LB CALC. BY Dm DATE ____

JOB NAME SHIC Joe Foss Field — CKED. BY MD SHEET ___ OF ___

ATTERBERG LIMITS WORKSHEET

HOLE / DEPTH	MW1 14GT / 12-14		MW-1 14GT / 17-19'		MW1-9 / 12-14		B1-2 / 42-44		B3-1 / 2-4	
SAMPLE NO. / RUN BY	/		/ QN		/ QN		/ QN		CONTAMINATED	
PREP. DISH / TRAY LOCAT.	PARTY /		PLANET /		BOY /		HOB /		DO:K / QN	
NO. OF BLOWS	P.L.		P.L.		P.L.		P.L.	20	P.L.	20
DISH NO.							63	23	38	58
WT. WET SOIL & DISH	N.P.L		N.P.L		N.P.L		22.65	34.44	22.34	32.04
WT. DRY SOIL & DISH							21.25	28.51	20.15	25.25
WT. OF DISH							11.34	10.87	10.95	11.69
WT. OF WATER										
WT. OF DRY SOIL										
WATER CONTENT Wn							14.13	33.60	23.80	50.07
LIQUID LIMIT LL							33		49	
PLASTIC INDEX PI							19		25	
CLASSIFICATION										

HOLE / DEPTH	B3-1 / 12-14		B3-5 / 2-4		B3.5 / 12-14		/		/	
SAMPLE NO. / RUN BY	/ QN		/ QN		/ QN		/		/	
PREP. DISH / TRAY LOCAT.	WIZARD /		NOTE /		CARBON /		/		/	
NO. OF BLOWS	P.L.		P.L.	28	P.L.		P.L.		P.L.	
DISH NO.			52	20						
WT. WET SOIL & DISH	N.P.L		22.21	30.86	N.P.L					
WT. DRY SOIL & DISH			20.23	24.17						
WT. OF DISH			11.79	10.90						
WT. OF WATER										
WT. OF DRY SOIL										
WATER CONTENT Wn			23.46	50.41						
LIQUID LIMIT LL			51							
PLASTIC INDEX PI			28							
CLASSIFICATION										

1-6 (5-85)

HYDROMETER

GRADATION ANALYSIS

WORKSHEET

LAB NO ____

JOB NO. 1-555-89 PART NO. 2 PREP. BY LR DATE 6-1

JOB NAME: SAIC Joe Foss Field CALC. BY QN CKED. BY QN

HOLE MW1 146T DEPTH 12-14 SAMPLE NO. ____

VISUAL DESCRIPTION: sand, v. silty clay, wet

RUN BY ____

SAMPLE PREPERATION

SIEVING TIME ____

SIEVE SIZE		3"	1 1/2"	3/4"	3/8"	NO.4
OF PAN AND SAMPLE						
WT. OF PAN						
DRY WT. RETAINED						
DRY WT. PASSING						7.0
% OF TOTAL PASSING					100	96
	W% =					

SAMPLE WEIGHTS	WET	DRY
TOTAL SAMPLE		167.5
RETAINED ON NO. 4		7.0
PASSING NO. 4		160.5

RUN BY QN

SIEVE AND HYDROMETER ANALYSIS

SIEVING TIME ____

FACTOR = W%/W = 96 = 1.899

SIEVE NO.	WEIGHT RETAINED	WEIGHT PASSING	% OF TOTAL PASSING
8 (10)	5.5		85
16	12.2		73
30 (40)	26.8		45
50	43.0		14
100	48.2		4.3
200	48.7		3.4
PAN			—
TOTAL			—

MOISTURE DETERMINATION

	+4 MATERIAL	-4 MATERIAL	HYGRO. MOISTURE	HYDRO. SAMPLE
DISH NO.			WANDA	
WT. WET SOIL AND DISH			350.8	50.61
WT. DRY SOIL AND DISH			350.5	
WT. DISH			241.0	
WT. OF DRY SOIL		= W		50.47
% MOISTURE			0.27	

RUN BY QN

HYDROMETER ANALYSIS

CYLINDER NO. 4 SPECIFIC GRAVITY ____ DISPERSING AGENT 4% NAPO3

DISH NO. ____ DATE 6-6-89 AMOUNT 125 ml DATE CALIB ____

CLOCK TIME	TEST TIME	TEMP. C°	HYD. READ	HYD.* CORR	CORR READ	FACTOR X CORRECTED READING = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIAMETER
7.57	START MIX	—	—	—	—		—	—
7.58	STOP MIX	—	—	—	—		—	—
~~—~~	~~0.5 min~~							0.050 mm
7.59	1.0 min	21.0	7.5	5.2	2.3		4.4	0.037 mm
8.02	4.0 min	21.0	7.0		1.8		3.4	0.019 mm
8.18	19 min	21.0	7.0		1.8		3.4	0.009 mm
8.59	60 min	21.0	6.5	v	1.3		2.5	0.005 mm
3.14	7h 15 min	22.0	6.0	4.9	1.1		2.1	0.002 mm
9.44	25h 45 min	21.0	6.0	5.2	.8		1.5	0.001 mm

GRAVEL 4 % SAND 93 % CLAY-SILT 3 %. STORAGE LOCATION ____

* CORRECTION INCLUDES TEMP., MENISCUS, AND DEFLOCULENT

DATE IN: ____ SUPERVISOR: ____

L-4 (5-85) LOCATION: ____

HYDROMETER

GRADATION ANALYSIS

WORKSHEET

LAB NO ______

JOB NO. 1-555-89 PART NO. 2 PREP. BY LR DATE 6-1

JOB NAME: SAIC Joe Foss Field CALC. BY JO CKED. BY DM

HOLE MW 1 14GT DEPTH 17-19 SAMPLE NO. ______

VISUAL DESCRIPTION: ______

SAMPLE PREPERATION

RUN BY ______ SIEVING TIME ______

SIEVE SIZE		3"	1 1/2"	3/4"	3/8"	NO.4
OF PAN AND SAMPLE						
WT. OF PAN						
DRY WT. RETAINED						
DRY WT. PASSING					4.1	18.6
% OF TOTAL PASSING				100	98	89
					W% =	

SAMPLE WEIGHTS	WET	DRY
TOTAL SAMPLE		162.7
RETAINED ON NO. 4		18.6
PASSING NO. 4		144.1

SIEVE AND HYDROMETER ANALYSIS

RUN BY QN SIEVING TIME ______

FACTOR = W% / W = 89 / 50.45 = 1.756

SIEVE NO.	WEIGHT RETAINED	WEIGHT PASSING	% OF TOTAL PASSING
8 (10)	14.3		63
16	24.4		46
30 (40)	28.2		39
50	34.4		28
100	45.0		10
200	48.0		4.3
PAN			—
TOTAL			—

MOISTURE DETERMINATION

	+4 MATERIAL	-4 MATERIAL	HYGRO. MOISTURE	HYDRO. SAMPLE
DISH NO.			SMALL	
WT. WET SOIL AND DISH			335.8	50.61
WT. DRY SOIL AND DISH			335.5	
WT. DISH			242.5	
WT. OF DRY SOIL		= W		50.45
% MOISTURE			0.32	

HYDROMETER ANALYSIS

RUN BY QN

CYLINDER NO. 5 SPECIFIC GRAVITY ______ DISPERSING AGENT 4% NAPO3

DISH NO. ______ DATE 6-6-89 AMOUNT 125 ml DATE CALIB ______

CLOCK TIME	TEST TIME	TEMP. C°	HYD. READ	HYD.* CORR	CORR READ	FACTOR X CORRECTED READING = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIAMETER	
8.01	START MIX	—	—	—	—		—	—	
8.02	STOP MIX	—	—	—	—		—	—	
~~—~~	~~0.5 min~~							0.050 mm	
8.03	1.0 min	21.0	7.5	5.2	2.3		4.0	0.037 mm	
8.06	4.0 min	21.0	7.0		1.8		3.2	0.019 mm	
8.22	19 min	21.0	7.0		1.8		3.2	0.009 mm	
9.03	60 min	21.0	7.0		1.8		3.2	0.005 mm	
3.18	7h 15 min	22.0	6.5	4.9	1.6		2.8	0.002 mm	
9.48	25h 45 min	21.0	6.5	5.2	1.3		2.3	0.001 mm	

GRAVEL 11 % SAND 85 % CLAY-SILT 4 %. STORAGE LOCATION ______

* CORRECTION INCLUDES TEMP., MENISCUS, AND DEFLOCULENT

DATE IN: ______ SUPERVISOR: ______

L-4 (5-85) LOCATION: ______

HYDROMETER

GRADATION ANALYSIS
WORKSHEET

LAB NO

JOB NO. 1-555-89 PART NO. PREP. BY DATE

JOB NAME: SAIC Joe Foss Field CALC. BY CKED. BY

HOLE MW-9 DEPTH 12-14 SAMPLE NO.

VISUAL DESCRIPTION: Sand, gravelly, med brown, wet, loose

RUN BY SAMPLE PREPERATION SIEVING TIME

SIEVE SIZE		3"	1 1/2"	3/4"	3/8"	NO.4
OF PAN AND SAMPLE						
WT. OF PAN						
DRY WT. RETAINED						
DRY WT. PASSING					13.8	48.1
% OF TOTAL PASSING				100	94	79
					W% =	

SAMPLE WEIGHTS	WET	DRY
TOTAL SAMPLE		231.4
RETAINED ON NO. 4		48.1
PASSING NO. 4		183.3

RUN BY QN SIEVE AND HYDROMETER ANALYSIS SIEVING TIME

FACTOR = W%/W = = 1.570

SIEVE NO.	WEIGHT RETAINED	WEIGHT PASSING	% OF TOTAL PASSING
8 (10)	13.5		58
16	23.1		43
30 (40)	34.3		25
50	44.4		10
100	47.8		4.2
200	48.4		3.2
PAN			—
TOTAL			—

MOISTURE DETERMINATION

	+4 MATERIAL	-4 MATERIAL	HYGRO. MOISTURE	HYDRO. SAMPLE
DISH NO.			UNTA	
WT. WET SOIL AND DISH			372.6	50.60
WT. DRY SOIL AND DISH			372.2	
WT. DISH			239.9	
WT. OF DRY SOIL		= W		50.45
% MOISTURE			0.3	

RUN BY QN HYDROMETER ANALYSIS

CYLINDER NO. 6 SPECIFIC GRAVITY DISPERSING AGENT 4% NAPO3

DISH NO. DATE 6-6-89 AMOUNT 125 ml DATE CALIB.

CLOCK TIME	TEST TIME	TEMP. C°	HYD. READ	HYD.* CORR	CORR READ	FACTOR x CORRECTED READING = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIAMETER	
8.05	START MIX	—	—	—	—		—	—	
8.06	STOP MIX	—	—	—	—		—	—	
	~~0.5 min~~							0.050 mm	
8.07	1.0 min	21.0	7.5	5.2	2.3		3.6	0.037 mm	
8.10	4.0 min	21.0	7.0		1.8		2.8	0.019 mm	
8.26	19 min	21.0	7.0		1.8		2.8	0.009 mm	
9.07	60 min	21.0	7.0		1.8		2.8	0.005 mm	
3.22	7h 15 min	22.0	6.5	4.9	1.6		2.5	0.002 mm	
9.52	25h 45 min	21.0	6.5	5.2	1.3		2.0	0.001 mm	

GRAVEL 21 % SAND 76 % CLAY-SILT 3 %. STORAGE LOCATION

✱ CORRECTION INCLUDES TEMP., MENISCUS, AND DEFLOCULENT

DATE IN: SUPERVISOR:

L-4 (5-85) LOCATION:

HYDROMETER

GRADATION ANALYSIS

WORKSHEET

LAB NO ________

JOB NO. 1-555-89 PART NO. ________ PREP. BY LB DATE 6-2

JOB NAME SAIC Joe Foss Field CALC. BY ________ CKED. BY ________

HOLE B1-2 DEPTH 42-44 SAMPLE NO. ________

VISUAL DESCRIPTION: ________

SAMPLE PREPERATION

RUN BY ________ SIEVING TIME ________

SIEVE SIZE		3"	1 1/2"	3/4"	3/8"	NO.4
OF PAN AND SAMPLE						
WT. OF PAN						
DRY WT. RETAINED						
DRY WT. PASSING						
% OF TOTAL PASSING						100
					W% =	

SAMPLE WEIGHTS	WET	DRY
TOTAL SAMPLE		
RETAINED ON NO. 4		
PASSING NO. 4		

SIEVE AND HYDROMETER ANALYSIS

RUN BY QN SIEVING TIME ________

FACTOR = W% / W = ________ = 2.005

SIEVE NO.	WEIGHT RETAINED	WEIGHT PASSING	% OF TOTAL PASSING
8 (10)	0.8		98
16	2.0		96
30 (40)	3.4		93
50	5.9		88
100	10.5		79
200	13.5		73
PAN			—
TOTAL			—

MOISTURE DETERMINATION

	+4 MATERIAL	-4 MATERIAL	HYGRO. MOISTURE	HYDRO. SAMPLE
DISH NO.			STOCK	
WT. WET SOIL AND DISH			319.9	50.73
WT. DRY SOIL AND DISH			318.0	
WT. DISH			208.9	
WT. OF DRY SOIL		= W		49.86
% MOISTURE			1.74	

HYDROMETER ANALYSIS

RUN BY QN

CYLINDER NO. 1 SPECIFIC GRAVITY ________ DISPERSING AGENT 4% NAPO3

DISH NO. ________ DATE 6-6-89 AMOUNT 125 ml DATE CALIB ________

CLOCK TIME	TEST TIME	TEMP. C°	HYD. READ	HYD.* CORR	CORR READ	FACTOR X CORRECTED READING = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIAMETER
7.45	START MIX	—	—	—	—		—	—
7.46	STOP MIX	—	—	—	—		—	—
~~—~~	~~0.5 min~~							0.050 mm
7.47	1.0 min	21.0	37.0	5.2	31.8		64	0.037 mm
7.50	4.0 min	21.0	31.0	5.2	25.8		52	0.019 mm
8.06	19 min	21.0	26.0	5.2	20.8		42	0.009 mm
8.47	60 min	21.0	23.0	5.2	17.8		36	0.005 mm
3.02	7h 15 min	22.0	19.0	4.9	14.1		28	0.002 mm
9.32	25h 45 min	21.0	17.0	5.2	11.8		24	0.001 mm

GRAVEL ________ % SAND 27 % CLAY-SILT 73 %. STORAGE LOCATION ________

* CORRECTION INCLUDES TEMP., MENISCUS, AND DEFLOCULENT

DATE IN: ________ SUPERVISOR: ________

L-4 (5-85) LOCATION: ________

HYDROMETER

GRADATION ANALYSIS WORKSHEET MATERIAL IN USE

LAB NO. ____

JOB NO. L-555-99 PART NO. 2 PREP. BY LB DATE 6-2
JOB NAME: SAIC Joe Foss Field CALC. BY DN CKED. BY [illegible]

HOLE B3-1 DEPTH 2-4 SAMPLE NO. ____
VISUAL DESCRIPTION: ____

RUN BY ____ SAMPLE PREPERATION SIEVING TIME ____

SIEVE SIZE		3"	1 1/2"	3/4"	3/8"	NO.4
OF PAN AND SAMPLE						
WT. OF PAN						
DRY WT. RETAINED						
DRY WT. PASSING						
% OF TOTAL PASSING						
	W% =					

SAMPLE WEIGHTS	WET	DRY
TOTAL SAMPLE		
RETAINED ON NO. 4		
PASSING NO. 4		

RUN BY DN SIEVE AND HYDROMETER ANALYSIS SIEVING TIME ____

FACTOR = W%/W = ____ = 2.0619

SIEVE NO.	WEIGHT RETAINED	WEIGHT PASSING	% OF TOTAL PASSING
8 (10)			
16			
30 (40)	0.2		100
50	0.6		99
100	2.6		95
200	3.9		92
PAN			—
TOTAL			—

MOISTURE DETERMINATION

	+4 MATERIAL	-4 MATERIAL	HYGRO. MOISTURE	HYDRO. SAMPLE
DISH NO.			PEARL	
WT. WET SOIL AND DISH			297.65	50.60
WT. DRY SOIL AND DISH			295.29	
WT. DISH			240.6	
WT. OF DRY SOIL		= W		48.50
% MOISTURE			4.32	

RUN BY DN HYDROMETER ANALYSIS

CYLINDER NO. 7 SPECIFIC GRAVITY ____ DISPERSING AGENT 4% NAPO3
DISH NO. ____ DATE 6-7-89 AMOUNT 125 ml DATE CALIB. ____

CLOCK TIME	TEST TIME	TEMP. C°	HYD. READ	HYD.* CORR	CORR READ	FACTOR X CORRECTED READING = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIAMETER
7.50	START MIX	—	—	—	—		—	—
7.51	STOP MIX	—	—	—	—		—	—
~~—~~	~~0.5 min~~							0.050 mm
7.52	1.0 min	21.0	48.0	5.2	42.8		88	0.037 mm
7.55	4.0 min	21.0	38.0	5.2	32.8		68	0.019 mm
8.11	19 min	21.0	31.0	5.2	25.8		53	0.009 mm
8.52	60 min	21.0	27.0	5.2	21.8		45	0.005 mm
3.07	7h 15 min	24.0	21.0	4.2	16.8		35	0.002 mm
9.37	25h 45 min	21.0	21.0	5.2	15.8		33	0.001 mm

GRAVEL ____% SAND 8 % CLAY-SILT 92 %. STORAGE LOCATION ____

* CORRECTION INCLUDES TEMP., MENISCUS, AND DEFLOCULENT

DATE IN: ____ SUPERVISOR: ____

L-4 (5-85) LOCATION: ____

HYDROMETER

GRADATION ANALYSIS

WORKSHEET

LAB NO ______

JOB NO. 1-555-89 PART NO. ______ PREP. BY LP DATE 6-2

JOB NAME : ______ CALC. BY QD CKED. BY DM

HOLE B3-1 DEPTH 12-14 SAMPLE NO. ______

VISUAL DESCRIPTION: 33 rd

SAMPLE PREPERATION

RUN BY ______ SIEVING TIME ______

SIEVE SIZE		3"	1 1/2"	3/4"	3/8"	NO.4
OF PAN AND SAMPLE						
WT. OF PAN						
DRY WT. RETAINED						
DRY WT. PASSING					14.6	63.7
% OF TOTAL PASSING				100	94	74
						% =

SAMPLE WEIGHTS	WET	DRY
TOTAL SAMPLE		249.3
RETAINED ON NO. 4		63.7
PASSING NO. 4		185.6

SIEVE AND HYDROMETER ANALYSIS

RUN BY QN SIEVING TIME ______

FACTOR = W% / W = ______ = 1.471

SIEVE NO.	WEIGHT RETAINED	WEIGHT PASSING	% OF TOTAL PASSING
8 (10)	17.6		49
16	25.2		37
30 (40)	31.4		28
50	41.1		14
100	46.8		5.6
200	47.4		4.7
PAN			—
TOTAL			—

MOISTURE DETERMINATION

	+4 MATERIAL	-4 MATERIAL	HYGRO. MOISTURE	HYDRO. SAMPLE
DISH NO.			FALL	
WT. WET SOIL AND DISH			376.8	50.74
WT. DRY SOIL AND DISH			376.5	
WT. DISH			241.8	
WT. OF DRY SOIL		= W		50.63
% MOISTURE			0.22	

HYDROMETER ANALYSIS

RUN BY QN

CYLINDER NO. 3 SPECIFIC GRAVITY ______ DISPERSING AGENT 4% NAPO3

DISH NO. ______ DATE 6-6-89 AMOUNT 125 ml DATE CALIB. ______

CLOCK TIME	TEST TIME	TEMP. C°	HYD. READ	HYD.* CORR	CORR READ	FACTOR X CORRECTED READING = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIAMETER
7.53	START MIX	—	—	—	—		—	—
7.54	STOP MIX	—	—	—	—		—	—
—	0.5 min							0.050 mm
7.55	1.0 min	21.0	8.5	5.2	3.3		4.9	0.037 mm
7.58	4.0 min	21.0	8.0		2.8		4.1	0.019 mm
8.14	19 min	21.0	8.0		2.8		4.1	0.009 mm
8.55	60 min	21.0	7.0		1.8		2.7	0.005 mm
3.10	7h 15 min	22.0	6.0	4.9	1.1		1.6	0.002 mm
9.40	25h 45 min	21.0	6.0	5.2	.8		1.2	0.001 mm

GRAVEL 26 % SAND 70 % CLAY-SILT 4 %. STORAGE LOCATION ______

* CORRECTION INCLUDES TEMP., MENISCUS, AND DEFLOCULENT

DATE IN: ______ SUPERVISOR: ______

L-4 (5-85) LOCATION: ______

HYDROMETER

GRADATION ANALYSIS

WORKSHEET

LAB NO ____

JOB NO. 155589 PART NO. 2 PREP. BY LR DATE 62

JOB NAME SAIC Ooe Jonj Field CALC. BY QQ CKED. BY MQ

HOLE B3-5 DEPTH 2-4 SAMPLE NO. ____

VISUAL DESCRIPTION: ____

SAMPLE PREPERATION

RUN BY ____ SIEVING TIME ____

SIEVE SIZE		3"	1 1/2"	3/4"	3/8"	NO.4
OF PAN AND SAMPLE						
WT. OF PAN						
DRY WT. RETAINED						
DRY WT. PASSING						
% OF TOTAL PASSING						
						W% = ____

SAMPLE WEIGHTS	WET	DRY
TOTAL SAMPLE		
RETAINED ON NO. 4		
PASSING NO. 4		

SIEVE AND HYDROMETER ANALYSIS

RUN BY QN SIEVING TIME ____

FACTOR = W%/W = ____ = 2.053 ✓

SIEVE NO.	WEIGHT RETAINED	WEIGHT PASSING	% OF TOTAL PASSING
8 (10)			
16	0.1		100 ✓
30 (40)	0.2		100 ✓
50	0.3		99 ✓
100	0.6		99 ✓
200	1.2		98 ✓
PAN			—
TOTAL			—

MOISTURE DETERMINATION

	+4 MATERIAL	-4 MATERIAL	HYGRO. MOISTURE	HYDRO. SAMPLE
DISH NO.			SMURT	
WT. WET SOIL AND DISH			293.4	50.44
WT. DRY SOIL AND DISH			291.6	
WT. DISH			241.0	
WT. OF DRY SOIL		____ = W		48.71 ✓
% MOISTURE			3.56 ✓	

HYDROMETER ANALYSIS

RUN BY QN

CYLINDER NO. 2 SPECIFIC GRAVITY ____ DISPERSING AGENT 4% NAPO3

DISH NO. ____ DATE 6-6-89 AMOUNT 125 ml DATE CALIB ____

CLOCK TIME	TEST TIME	TEMP. C°	HYD. READ	HYD.* CORR	CORR READ	FACTOR X CORRECTED READING = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIAMETER
7.49	START MIX	—	—	—	—		—	—
7.50	STOP MIX	—	—	—	—		—	—
	~~0.5 min~~							0.050 mm
7.51	1.0 min	21.0	47.0	5.2	41.8		86 ✓	0.037 mm
7.54	4.0 min	21.0	37.0	|	31.8		65 ✓	0.019 mm
8.10	19 min	21.0	29.0		23.8		49 ✓	0.009 mm
8.51	60 min	21.0	25.0	✓	19.8		41 ✓	0.005 mm
3.06	7h 15 min	22.0	21.0	4.9	16.1		33 ✓	0.002 mm
9.36	25h 45 min	21.0	19.0	5.2	138		28 ✓	0.001 mm

GRAVEL ____ % SAND 2 % CLAY-SILT 98 %. STORAGE LOCATION ____

* CORRECTION INCLUDES TEMP., MENISCUS, AND DEFLOCULENT

DATE IN: ____ SUPERVISOR: ____

L-4 (5-85) LOCATION: ____

GRADATION ANALYSIS

WORKSHEET

LAB NO ____

JOB NO. L-555-89 PART NO. 2 PREP. BY LB DATE 6-3

JOB NAME: SAIC Joe Foss Field CALC. BY ON CHECKED. BY

HOLE B3-5 DEPTH 12-14 SAMPLE NO. ____

VISUAL DESCRIPTION: [illegible] lt moist HCL-e

RUN BY ____ **SAMPLE PREPERATION** SIEVING TIME ____

SIEVE SIZE		3"	1 1/2"	3/4"	3/8"	NO.4
OF PAN AND SAMPLE						
WT. OF PAN						
DRY WT. RETAINED						
DRY WT. PASSING						4.0
% OF TOTAL PASSING						98
	W% =					

SAMPLE WEIGHTS

	WET	DRY
TOTAL SAMPLE		243.6
RETAINED ON NO. 4		4.0
PASSING NO. 4		239.6

RUN BY ON **SIEVE AND HYDROMETER ANALYSIS** SIEVING TIME ____

FACTOR = W%/W = ____ = 1.9558

SIEVE NO.	WEIGHT RETAINED	WEIGHT PASSING	% OF TOTAL PASSING
8 (10)	2.8		93
16	8.5		82
30 (40)	27.1		45
50	44.6		11
100	47.6		5
200	47.8		5
PAN			—
TOTAL			—

MOISTURE DETERMINATION

	+4 MATERIAL	-4 MATERIAL	HYGRO. MOISTURE	HYDRO. SAMPLE
DISH NO.			HEBREWS	
WT. WET SOIL AND DISH			431.0	50.43
WT. DRY SOIL AND DISH			430.5	
WT. DISH			241.9	
WT. OF DRY SOIL		= W		50.29
% MOISTURE			.27	

RUN BY ON **HYDROMETER ANALYSIS**

CYLINDER NO. 9 SPECIFIC GRAVITY ____ DISPERSING AGENT 4% NAPO3

DISH NO. ____ DATE 6-7-89 AMOUNT 125 ml DATE CALIB ____

CLOCK TIME	TEST TIME	TEMP. C°	HYD. READ	HYD.* CORR	CORR READ	FACTOR X CORRECTED READING = % OF TOTAL PASSING	% OF TOTAL PASSING	PARTICLE DIAMETER
7.58	START MIX	—	—	—	—		—	—
7.59	STOP MIX	—	—	—	—		—	—
	~~0.5 min~~							0.050 mm
8.00	1.0 min	21.0	7.5	5.2	2.3		4	0.037 mm
8.03	4.0 min	21.0	7.0	5.2	1.8		4	0.019 mm
8.19	19 min	21.0	7.0	5.2	1.8		4	0.009 mm
9.00	60 min	21.0	7.0	5.2	1.8		4	0.005 mm
3.15	7h 15 min	24.0	5.5	4.2	1.3		3	0.002 mm
9.45	25h 45 min	21.0	6.5	5.2	1.3		3	0.001 mm

GRAVEL 2 % SAND 93 % CLAY-SILT 5 %. STORAGE LOCATION ____

* CORRECTION INCLUDES TEMP., MENISCUS, AND DEFLOCULENT

DATE IN: ____ SUPERVISOR: ____

L-4 (5-85) LOCATION: ____

JOB NO. 1-555-8? PART NO. 2

chen and associates, inc.

ORGANIC MATTER IN SOILS WORKSHEET

PREP./RUN BY LB/BM DATE 6/

JOB NAME SAIC Joe Foss Field

CALC. BY BM CKED. BY AP

HOLE/DEPTH SAMPLE NO.	SAMPLE WT. (gms.)	TITER Normality	x ml. added	= me	TITRANT Normality	x (Finish-Start) ml.	= me	% TITER CONSUMED	ORGANIC MATTER (%)
MW-1 14GT 12-14	1.44	2.05	10	20.5	.5	40.4-3.0	18.7		.74

REMARKS: Dish -> Bob Flask 1 (6-7)

HOLE/DEPTH SAMPLE NO.	SAMPLE WT. (gms.)	TITER Normality	x ml. added	= me	TITRANT Normality	x (Finish-Start) ml.	= me	% TITER CONSUMED	ORGANIC MATTER (%)
MW-1 14GT 17-19'	2.02	2.05	10	20.5	.5	39.3-2.9	18.2		.67

REMARKS: dish -> Minor Flask 6 (6-7

HOLE/DEPTH SAMPLE NO.	SAMPLE WT. (gms.)	TITER Normality	x ml. added	= me	TITRANT Normality	x (Finish-Start) ml.	= me	% TITER CONSUMED	ORGANIC MATTER (%)
MW1-9 12-14'	1.66	2.05	10	20.5	.5	41.9-2.1	19.9		.21

REMARKS: Dish - Walnut Flask 2 (6-6)

HOLE/DEPTH SAMPLE NO.	SAMPLE WT. (gms.)	TITER Normality	x ml. added	= me	TITRANT Normality	x (Finish-Start) ml.	= me	% TITER CONSUMED	ORGANIC MATTER (%)
B-1-2 42-44	1.30	2.05	10	20.5	.5	36.1-0.9	17.6		1.32

REMARKS: Dish -> Hondo Flask 4 (6-6)

HOLE/DEPTH SAMPLE NO.	SAMPLE WT. (gms.)	TITER Normality	x ml. added	= me	TITRANT Normality	x (Finish-Start) ml.	= me	% TITER CONSUMED	ORGANIC MATTER (%)
B3-1 2-4	1.47	2.05	10	20.5	.5	33.6-5.7	13.95		2.63

REMARKS: CONTAMINATED Dish -> ~~special~~ Flask 5 (6-7)

HOLE/DEPTH SAMPLE NO.	SAMPLE WT. (gms.)	TITER Normality	x ml. added	= me	TITRANT Normality	x (Finish-Start) ml.	= me	% TITER CONSUMED	ORGANIC MATTER (%)
B3-1 12-14	1.29	2.05	10	20.5	.5	43.7-3.4	20.1		.16

REMARKS: Dish -> ~~Grove~~ Flask 6 (6-6)

L-38 5-85)

JOB NO. L-55589 PART NO. 2

chen and associates, inc.

ORGANIC MATTER IN SOILS

WORKSHEET

PREP./RUN BY LB/BW DATE 6-6

JOB NAME SHK Joe Foss Field

CALC. BY RM CKED. BY AJ

HOLE/DEPTH SAMPLE NO.	SAMPLE WT. (gms.)	TITER Normality x ml. added = me			TITRANT Normality x (Finish-Start) ml. = me			% TITER CONSUMED	ORGANIC MATTER (%)
B3.5 24'	1.26	2.05	10	20.5	.5	32.0-6.1	12.95		3.54

REMARKS: GERTY Flask 8 (6-6)

HOLE/DEPTH SAMPLE NO.	SAMPLE WT. (gms.)	TITER Normality x ml. added = me			TITRANT Normality x (Finish-Start) ml. = me			% TITER CONSUMED	ORGANIC MATTER (%)
B3.5 12-14	1.79	2.05	10	20.5	.5	44.6-4.7	19.95		.18

REMARKS: DAISY Flask 8 (6-7)

HOLE/DEPTH SAMPLE NO.	SAMPLE WT. (gms.)	TITER Normality x ml. added = me			TITRANT Normality x (Finish-Start) ml. = me			% TITER CONSUMED	ORGANIC MATTER (%)

REMARKS:

HOLE/DEPTH SAMPLE NO.	SAMPLE WT. (gms.)	TITER Normality x ml. added = me			TITRANT Normality x (Finish-Start) ml. = me			% TITER CONSUMED	ORGANIC MATTER (%)

REMARKS:

HOLE/DEPTH SAMPLE NO.	SAMPLE WT. (gms.)	TITER Normality x ml. added = me			TITRANT Normality x (Finish-Start) ml. = me			% TITER CONSUMED	ORGANIC MATTER (%)
		2.055	10.0	20.55	.5	42.9-1.8	20.55		

REMARKS: Standard 6-7 Flask 4

HOLE/DEPTH SAMPLE NO.	SAMPLE WT. (gms.)	TITER Normality x ml. added = me			TITRANT Normality x (Finish-Start) ml. = me			% TITER CONSUMED	ORGANIC MATTER (%)
Standard	0	2.05	10	20.50	.5	41.8-0.8	20.5		

REMARKS: 6-6

L-38 5-85)

COLORADO ANALYTICAL LABORATORY

SOIL WATER ENVIRONMENTAL

LABORATORY ANALYSIS REPORT

REPORT TO: Norman Lewis

LAB NO: 8363

DATE RCVD: 4-21-89

BILL TO: Chen-Northern, Inc.
96 South Zuni
Denver, CO 80223

REPORTED: 5-4-89

P.O. #:

ANALYSIS REQUESTED:
13 Soils for CEC - (EPA Method 9081)

Chen Job #: 1-555-89

ANALYSIS REPORT:

Sample ID:	CEC (meq/100g)
B1-1-15	1.9
B1-1-25	2.4
B1-2-15	0.8
B1-2-25	2.0
B3-1-0	22.7
B3-2-5	22.6
B3-3-2.5	28.4
B3-4-0	31.8
B3-5-2.5	39.7
MW1-5-15	1.2
MW1-6-20	1.3
MW1-7-15	3.0
MW1-8-20	1.1

Analysis Supervised by

Data Approved for Release by

240 S. Main Street • Brighton, Colorado 80601 • (303) 659-2313
Mailing Address: P.O. Drawer 507, Brighton, CO 80601

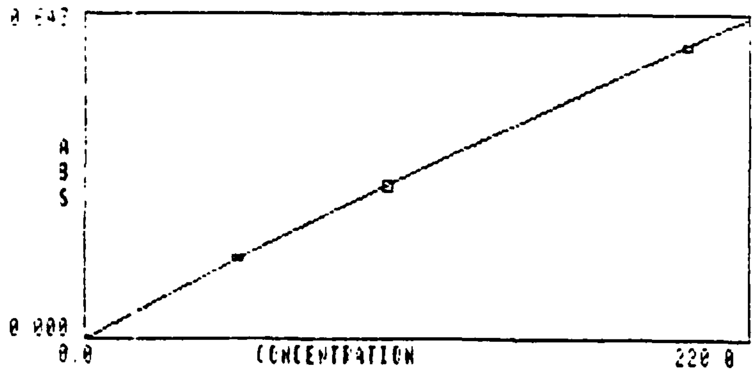
Varian Spectra 10/20 System Report.

OPERATOR [illegible]
DATE [illegible]
BATCH [illegible]

PROGRAM 21 Na

INSTRUMENT MODE	ABSORBANCE
CALIBRATION MODE	CONCENTRATION
MEASUREMENT MODE	INTEGRATION
LAMP CURRENT (mA)	5
SLIT WIDTH (nm)	0.5
WAVELENGTH (nm)	589.6
FLAME	AIR-ACETYLENE
SAMPLE INTRODUCTION	MANUAL
DELAY TIME (sec)	2
TIME CONSTANT	0.05
MEASUREMENT TIME (sec)	1.0
REPLICATES	2
BACKGROUND CORRECTION	OFF
ACETYLENE FLOW	1.5
RECALIBRATION RATE	0
RESLOPE RATE	0

SAMPLE	CONC	%RSD	MEAN ABS	READINGS	
BLANK	0.0		0.004	0.003	0.004
STANDARD 1	50.0	0.0	0.157	0.157	0.157
STANDARD 2	100.0	1.6	0.304	0.307	0.300
STANDARD 3	200.0	0.1	0.584	0.584	0.585



163.1	18.0	1.6	0.056	0.057	0.056
163.2	21.9	1.3	0.069	0.068	0.069
163.3	7.3	2.8	0.023	0.023	0.023
163.4	18.6	0.2	0.058	0.058	0.058
163.5	209.2	1.4	0.609	0.603	0.615

SAMPLE	CONC	RSD	MEAN ABS		ABSORBANCE	
[illegible]63.6	207.[illegible]	0.9	0.[illegible]	0.602	0.[illegible]	
[illegible]63.7	OVER	1.0	0.753	0.759	0.748	
[illegible]63.[illegible]	OVER	0.9	0.827	0.828	0.812	
[illegible]63.9	OVER	2.7	0.784	0.969	1.[illegible]	
[illegible]63.10	11.0	1.7	0.074	0.074	0.073	
[illegible]63.[illegible]	OVER	2.2	0.993	0.977	1.[illegible]	
[illegible]67.11	12.1	7.9	0.038	0.029	0.027	
[illegible]63.12	27.2	2.1	0.085	0.084	0.087	
[illegible]63.13	10.1	0.3	0.032	0.032	0.032	
~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	WRONG SAMPLE
63.1	16.9	1.2	0.053	0.052	0.051	
00.0	-0.6	52.2	-0.001	-0.003	-0.001	
[illegible]63.7 1:10	18.1	0.1	0.082	0.082	0.082	
[illegible]63.8 1:10	25.2	1.1	[illegible]	0.071	0.[illegible]72	
[illegible]63.9 1:10	35.5	1.1	0.114	0.113	0.115	
[illegible] STD	[illegible]	0.4	0.[illegible]	0.30[illegible]	0.301	
~~[illegible]~~	~~[illegible]~~	~~54.[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	No Sample

1st setup SW

CATION EXCHANGE CAPACITY (SODIUM ACETATE METHOD)

WAVELENGTH : ~~294~~ 589.6 SLIT: 0.5 ELEMENT: SODIUM LAMP: Na/K mA: 5 DATE: 5-3-89

STANDARDS USED: SETUP CONC 50 SETUP 50.0, CONC 100 SETUP 100.0 LAB #: 8363

in (Na_2CO_3) OTHER CONC 200 READING 200.0, CONC ____ READING ____ CLIENT: CHEN NORTHERN INC.

LAB NO.	SAMPLE WT. (GRAMS)	MOISTURE DETERMINATION PAN & SAMPLE	AD(g)	TARE(g)	CENTRIFUGE TUBE #	PPM Na	CEC (MEQ/100g)	BY	REV BY/ DATE
8363.01	4.00g	N/A - AD			1	18.0	~~2.0~~ 1.9	Ahn	
8363.02					2	21.9	2.4	Ahn	
8363.03					3	7.3	0.8	Ahn	
8363.04					4	18.6	2.0	Ahn	
8363.05					5	209.2	22.7	Ahn	
8363.06					6	207.9	22.6	Ahn	
8363.07					X7	261.	28.4	Ahn	
8363.08					X8	293.	31.8	Ahn	
8363.09					X1	365.	39.7	Ahn	
8363.10					2	11.0	1.2	Ahn	
R-01					3	16.9	~~1.8~~	Ahn	
					$\bar{X}=2.0+1.8=1.9$				
8363.11					4	12.1	1.3	Ahn	
8363.12					5	27.2	3.0	Ahn	
8363.13					6	10.1	1.1	Ahn	
BLANK	0				7	2.1	—	Ahn	

Sample Calculation

SAMPLE LIST

CLIENT: CHEN NORTHERN INC.

LAB #	SAMPLE ID	
8363 . 1	B1-1-15	DATE RCVD: 4-21-89
8363 . 2	B1-1-25	DATE RCVD: 4-21-89
8363 . 3	B1-2-15	DATE RCVD: 4-21-89
8363 . 4	B1-2-25	DATE RCVD: 4-21-89
8363 . 5	B3-1-0	DATE RCVD: 4-21-89
8363 . 6	B3-2-5	DATE RCVD: 4-21-89
8363 . 7	B3-3-2.5	DATE RCVD: 4-21-89
8363 . 8	B3-4-0	DATE RCVD: 4-21-89
8363 . 9	B3-5-2.5	DATE RCVD: 4-21-89
8363 . 10	MW1-5-15	DATE RCVD: 4-21-89
8363 . 11	MW1-6-20	DATE RCVD: 4-21-89
8363 . 12	MW1-7-15	DATE RCVD: 4-21-89
8363 . 13	MW1-8-20	DATE RCVD: 4-21-89

COLORADO ANALYTICAL LABORATORY

SOIL WATER ENVIRONMENTAL

LABORATORY ANALYSIS REPORT

REPORT TO: Norman Lewis

LAB NO: 8464

DATE RCVD: 6-7-89

BILL TO: Chen-Northern
96 South Zuni
Denver, CO 80223

REPORTED: 6-20-89

P.O. #: 50984

==

ANALYSIS REQUESTED:
10 Soil Samples for CEC - (EPA Method 9081)

Chen Job #: 1-555-89

==

ANALYSIS REPORT:

Sample ID:	CEC (meq/100g)
MW1-9-20	1.5
MW1-10-20	1.3
MW1-11-20	3.8
MW-1-12-20	1.3
BK-2-15	0.9
BK-2-20	1.0
BK-2-25	1.1
BK-3-.05	30.3
BK-3-5	13.0
BK-3-20	3.4

Shaun Nilson
Analysis Supervised by

Stanley Nelson
Data Approved for Release by

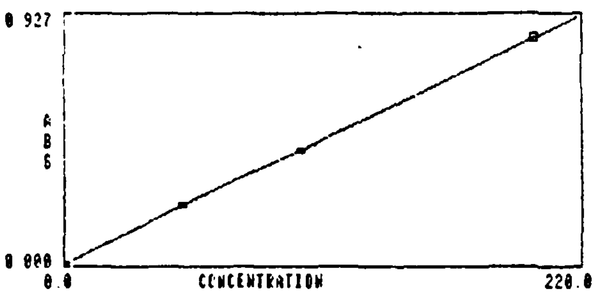
240 S. Main Street • Brighton, Colorado 80601 • (303) 659-2313
Mailing Address: P.O. Drawer 507, Brighton, CO 80601

OPERATOR [illegible]
DATE [illegible] 89
BATCH NO. 8464

PROGRAM 11 Na

INSTRUMENT MODE	[illegible]
CALIBRATION MODE	CONCENTRATION
MEASUREMENT MODE	INTEGRATION
LAMP CURRENT (mA)	5
SLIT WIDTH (nm)	0.5
WAVELENGTH (nm)	589.[illegible]
FLAME	AIR-ACETYLENE
SAMPLE INTRODUCTION	MANUAL
DELAY TIME	2
TIME CONSTANT	0.05
MEASUREMENT TIME (sec)	1.0
REPLICATES	2
BACKGROUND CORRECTION	OFF

SAMPLE	CONC	%RSD	MEAN ABS	READINGS	
BLANK	0.0		0.002	0.002	0.002
STANDARD 1	50.0	0.7	0.224	0.223	0.225
STANDARD 2	100.0	0.5	0.425	0.426	0.423
STANDARD 3	200.0	0.5	0.842	0.840	0.845



SAMPLE	CONC	%RSD	MEAN ABS	READINGS	
8464.1	13.5	0.0	0.063	0.063	0.062

SAMPLE	CONC	%RSD	MEAN ABS	READINGS	
8464.2	12.0	0.9	0.054	0.054	0.054
8464.3	35.2	1.2	0.158	0.157	0.159
8464.4	11.7	0.5	0.053	0.053	0.052
8464.5	8.4	2.2	0.038	0.037	0.038
8464.6	8.8	2.7	0.040	0.039	0.040
8464.7	10.0	1.7	0.045	0.045	0.044
8464.8	OVER	0.0	1.191	1.191	1.191
8464.9	119.2	0.1	0.505	0.506	0.505
8464.10	31.0	0.2	0.139	0.139	0.139
8464.8	27.9	0.3	0.125	0.125	0.126
10[illegible]	101.1	0.5	0.429	0.428	0.431
[illegible].0	1.2	79.2	0.006	0.009	0.002

WAVELENGTH : 589.6 SLIT: 0.5 ELEMENT: SODIUM LAMP: Na/K MA: 5 DATE: 6-19-89

STANDARDS USED: SETUP, CONC 50 SETUP 50.0, CONC 100 SETUP 100.0

OTHER - CONC 200 READING 200.0, CONC ____ READING ____

LAB #: 8464

CLIENT: CHEN-NORTHERN

LAB NO.	SAMPLE WT. (GRAMS)	MOISTURE DETERMINATION PAN & SAMPLE	AD(g)	TARE(g)	CENTRIFUGE TUBE #	PPM Na	CEC (MEQ/100g)	BY	REV BY DATE
8464.01	4	not	Done		1	~~12.0~~ 13.9	1.51	Han	
8464.02	4	not	Done		2	~~35.2~~ 12.0	1.31	Han	
8464.03	4	NOT	Done		3	~~11.7~~ 35.2	3.83	Han	
8464.04	4	NOT	Done		4	~~8.4~~ 11.7	1.27	Han	
8464.05	4	NOT	Done		5	~~10.0~~ 8.4	0.914	Han	
8464.06	4	NOT	Done		6	~~279~~ 8.8	0.957	Han	
8464.07	4	NOT	Done		7	10.0	1.09	Han	
8464.08	4	NOT	Done		8	279.	30.3	Han	
8464.09	4	NOT	Done		1	~~TOT~~ 119.2	13.0	Han	
8464.10	4	NOT	Done		2	31.0	3.37	Han	
						see attached AA sheet			

Sample Calculation

CEC (meq/100g) = ((mg/l Na in flask x 10)/23) / sa s...

Sample # 8464.01 CEC = 13.9 x10 /... 1.51 meq/100 g